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A Study of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emissions

Vol. 5 experimental investigation of service organization maintenance performance

TRW Systems Group

prepared for

Environmental Protection Agency

JULY 1972

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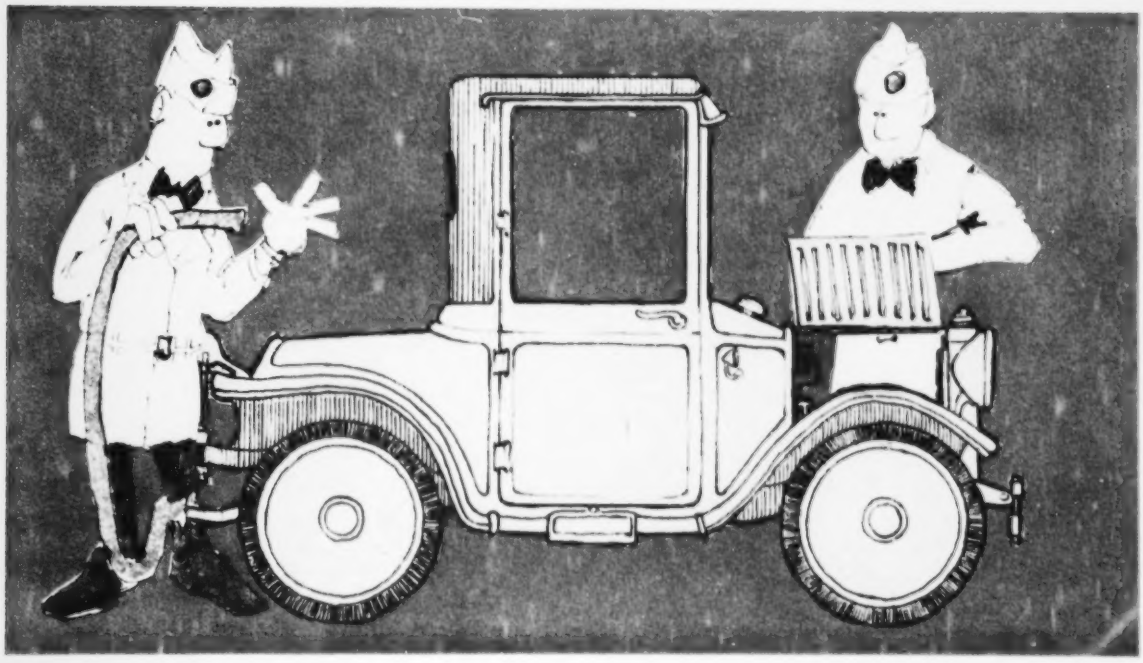
Volume V. Experimental Investigation of Service Organization Maintenance Performance



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PREFACE

This report, "A Study of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emissions," consists of six volumes. The following are the subtitles given for each volume:

- Executive Summary, Volume I
- Mandatory Inspection/Maintenance Systems Study, Volume II
- A Documentation Handbook for the Economic Effectiveness Model, Volume III
- Experimental Characterization of Vehicle Emissions and Maintenance States, Volume IV
- Experimental Characterization of Service Organization Maintenance Performance, Volume V
- A Comparison of Oxides of Nitrogen Measurements Made With Chemiluminescent and Non-Dispersive Radiation Analyzers, Volume VI

The first volume summarizes the general objectives, approach and results of the study. The second volume presents the results of the mandatory inspection/maintenance system study conducted with a computerized system model which is described in Volume III. The experimental programs conducted to develop input data for the model are described in Volume IV (Interim Report of 1971-72 Test Effort) and V. Volume VI presents comparative measurements of NO and NO_x using chemiluminescence and NDIR/NDUV instruments and differences in these measurements are examined.

The work presented herein is the product of a joint effort by TRW Systems Group and its subcontractor, Scott Research Laboratories. TRW, as the prime contractor, was responsible for overall program management, experimental design, data management and analysis, and the economic effectiveness study. Scott acquired and tested all of the study vehicles. Scott also provided technical assistance in selecting emission test procedures and in evaluating the test results.

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1.0 INTRODUCTION

The overall objective of this experiment was to develop measures of service organization effectiveness in correcting engine part failures, malfunctions and tune-up parameter maladjustments which cause high exhaust emissions. Subsidiary objectives were to assess the capability of service organizations to:

- Detect specific malfunctions, maladjustments and failures
- Return malfunctions, maladjustments and failures to manufacturer's specifications
- Respond to the type of information which might be provided by mandatory vehicle inspection and the resulting impact on cost and performance effectiveness.

It was also desired to develop statistics on the:

- Cost to accomplish maintenance
- Maintenance cost and performance effectiveness of garages organizations in different communities
- Influence of service organization type (independent, dealership and service station) on cost and performance effectiveness
- The amount of unnecessary maintenance performed by service organizations.

Quantitative data from these experiments which describes service organization performance of maintenance which influences exhaust emissions and maintenance costs are to be synthesized for use in the Economic Effectiveness Model.

The experimental program was conducted by systematically introducing known malfunctions and maladjustments into test automobiles and submitting the vehiclesto service organizations for repair. The malfunctions were selected to be representative of the type of part failures and engine parameter maladjustments found in the CAPE-13 Phase I engine parameter survey while the levels of maladjustments were set to reflect the cost optimum rejection levels predicted by the Economic Effectiveness Model. The malfunctions are grouped by: Idle adjustments (RPM, F/A ratio, timing) ignition system malfunctions (misfire from spark plug or ignition wire) induction system upset (air cleaner plugging, PCV valve

failure), choke system failure (heat riser failure and blade setting), NO_x device failure and confounding malfunctions (rich float level and valve failure).

The maladjusted vehicles were sent to service organizations for repair. After service had been completed, Scott inspected the vehicles to determine how well the maintenance organizations were able to detect and repair the deliberately introduced malfunctions. The repair costs were recorded and an estimate was made of unnecessary repairs performed on each vehicle.

This report describes: (1) the program experimental design, (2) experimental problems, (3) program results, and (4) recommendations for further action.

2.0 MANDATORY INSPECTION MAINTENANCE APPROACHES SELECTED FOR INVESTIGATION

The TRW Economic Effectiveness study showed two basic inspection approaches to be economically feasible for a mandatory vehicle inspection/maintenance program.

- A program in which a service organization would examine engine parameter settings and components and repair those items out of specification
- A program in which an actual emission measurement is made, and data supplied to the repair agency describing the probable malfunctions and maladjustments which would produce the measured high emissions.

In the experimental program, service organizations were provided with maintenance data and instructions typical of that which might be provided by each of these inspection processes.

The first inspection method requires direct inspection of engine parameters using commercially available diagnostic equipment and procedures. Since California class "A" service organizations are likely to use the most up to date commercially available engine parameter diagnostic equipment and procedures, the inspection and repair of vehicles by these organizations was considered representative of the best current state of art of repair organizations. The experimental program therefore directly evaluates the effectiveness of service organizations to diagnose and maintain vehicles following a direct engine parameter inspection.

The second inspection method involves the measurement of exhaust emissions under one or more engine operating conditions. Service organizations then are provided with a list of probable vehicle maladjustments and malfunctions based upon the resulting emissions data. The emissions data also are provided. It was conceivable that the cost and reliability of repair would be enhanced by the additional information, even though the service organizations would still rely upon their standard commercial diagnostic equipment and procedures. Data obtained from this portion of

the program was used to evaluate service organization ability to diagnose and maintain vehicles given data of the type obtainable from an exhaust emission inspection.

Because the program was structured on the basis of the two inspection/maintenance procedures, the test vehicles were divided into an engine parameter inspection fleet and an emission inspection fleet.

3.0 VEHICLE AND ENGINE PART FAILURE OR MALADJUSTMENT SELECTION

This section describes the criteria and methodology used in the selection of test vehicles and engine part failures or maladjustments.

3.1 VEHICLE SELECTION

Five test vehicles each were selected for the engine parameter inspection fleet and the emission inspection fleet. The mix of vehicles by manufacturer was approximately in proportion to the national vehicle population. All vehicles were equipped with popular engine/drive line combinations (V-8 engines primarily with automatic transmissions) except for the Volkswagon and American Motors vehicles.

It was estimated that the time required for a service organization to process a vehicle would vary between one and two days. Thus the number of vehicles used in the test program was determined to allow scheduling of test vehicles into service organizations while maintaining a responably stable work load at the Scott facility for setting up malfunctions and checking service organization performance. In order to determine whether service organizations would be biased in their performance by high mileage, older vehicles,one 1965 pre-emission controlled GM vehicle was selected for each fleet.

3.2 MALFUNCTION SELECTION

The goal was to introduce a large enough number of maladjustments and malfunctions into each test vehicle to provide a data base of sufficient size to evaluate the service organization detection and maintenance capability while limiting malfunctions and maladjustments to those that could reasonably be expected to occur in each particular vehicle.

Figure 3.1 shows the selected test vehicles and the parameter malfunctions or deviations from the manufacturers' specifications which were incorporated in each vehicle. The levels of deviation were based both on the extent of maladjustment indicated in the CAPE-13 Phase I parameter

Figure 3.1

SIMS 1A

Garage Evaluation Fleet - Vehicle Malfunction Distribution

Primary Malfunction - Deviation From Nominal Specification

Vehicle Identification			Idle		Timing		Misfire		Induction System		Choke System		Confounding Malfunction
Car	Manufacturer	Insp. Type	% CO	rpm	Basic	NO_x Control	Plug Wire	Spk. Plug	Air Clnr. % CO[3]	PCV	Heat Riser	Blade Setting	
1	G.M.[1]	Emiss.	+3.0	0	+10	--	(--)	--	(+.5)	(Failed[4])	(Failed[6])	--	Rich Float Level
2	Ford	"	+3.5	-70	+2	--	12%	--	--	--	--	--	Bent Push Rods
3	G.M.	"	+3.5	-70	+2	(Inoper.)	(12% D)	--	(--)	(--)	--	--	--
4	Chry.	"	+3.0	0	+10	--	--	--	+.5	(--)	--	--	--
5	VW[2]	"	0	+50	-10	(--)	--	(6%)	--	--	(--)	(--)	--
6	Chry.	Param.	0	+50	+10	Inoper.	--	--	--	--	Failed[5]	-1/8"(Rich)	--
7	G.M.[1]	"	+4.0	-50	+7	--	(--)	(--)	+.2	(Failed)	--	--	--
8	Ford	"	+4.0	-50	+10	--	--	6%	+.2	--	--	--	--
9	G.M.	"	+3.5	-150	+10	Inoper.	(12%)	(6%)	--	(--)	Failed[6]	-1/8"(Rich)	--
10	AMC[2]	"	+3.5	-150	-5	Inoper.	--	--	--	(--)	(--)	--	--

NOTES:
1 Pre-controlled vehicle, all others are 1970-71 vehicles
2 All vehicles are V-8's except AMC and VW
3 Or 180° maximum on AC tester
4 Plugged
5 Open
6 Closed
D Disconnected

( ) - indicates change from original chart

survey data and the optimum rejection levels predicted by the Economic/ Effectiveness Model. The number of malfunctions selected for a single vehicle as well as the total number of malfunctions studied was constrained to conform to the following additional criteria:

- The malfunctions were apportioned as equally as possible among vehicles
- A minimum test sample size (across the total vehicle sample) of 90 was required for each parameter under study

In addition, confounding malfunctions of two types were introduced into vehicles of the emission inspection fleet. These were malfunctions which would result in high emissions under several engine operating modes, and would tend to mask the influence of the particular parameters under evaluation. For example, vehicle #1 contained a number of induction system related malfunctions causing high CO emissions under load. In addition, the carburetor float level was set to cause rich mixture, thus resulting in even higher CO and HC emissions. A choke-related malfunction (heat riser fixed open) which would not be detected by tests performed with a hot engine was also introduced. Vehicle #2 contained a number of engine parameter maladjustments which tended to cause high HC emissions under load. A bent push rod was introduced as a confounding malfunction (simulating valve failure) to mask a misfire malfunction.

The objective of introducing confounding malfunctions was to assess whether the service organization would over-react to confounding malfunctions by over-repairing the carburetor rather than maintaining simple components (PCV and air cleaner which also affect carburetor metering) by failing to detect the heat riser failure because it would not be detected by hot engine inspection, or by failing to detect the misfire malfunction since the simulated valve failure would have the same effect on emissions.

Vehicles 1 through 5 made up the emission inspection fleet. Vehicles 6 through 10 the parameter inspection fleet. As can be seen from Figure 3.1, a pre-controlled vehicle was included in each fleet. These older vehicles allowed the introduction of malfunctions likely to occur in older vehicles which are not probable in later model year vehicles.

This matrix of malfunctions resulted in a higher number of malfunctions per vehicle than is normally encountered, but it was judged that the cost to conduct the experiment would be prohibitive if fewer malfunctions were introduced in each vehicle. The high number of malfunctions in each test vehicle did cause some problems with service organizations, (discussed in detail in paragraph 4.5.6) but were judged not to have greatly influenced the experimental results.

4.0 EXPERIMENTAL PROGRAM

This section describes the experimental program conducted by Scott Research Laboratories, Inc.

4.1 VEHICLE INITIAL PREPARATION

Each vehicle received a major tune-up prior to the introduction of malfunctions. The tune-up included replacement of sparkplugs, points, condensers, distributor rotor, distributor cap, PCV valve, complete diagnostic check and maintenance of the distributor assembly, new ignition harness and air filter element. The complete inspection of all engine parameters was accomplished as described in the following pages. Extreme care was taken in preparing vehicles to eliminate uncertainties in vehicle operating condition which might cause confounding of the experimental results.

The following sixteen (16) items were inspected by a Scott mechanic for deviation from specification or failure.

1. Basic timing
2. Idle rpm
3. Idle mixture
4. Dwell
5. Misfire
   a. wires
   b. plugs
6. PCV valve
7. Air cleaner element
8. Vacuum hose leaks
9. NO_x devices
10. Other special devices
11. Point opening variation
12. Mechanical advance
13. Vacuum advance
14. Manifold vacuum
15. Choke setting
16. Heat riser valve

The inspection sheet used for recording deviations is shown in Figure 4.1, Engine Parameter Inspection Summary. All required repairs or adjustments were performed, including inspection and maintenance of crankcase oil, transmission fluid and cooling system, to put the vehicles in factory specification operating condition. The vehicles were then ready for the

Engine Parameter Inspection
Performed By
SCOTT RESEARCH LABORATORIES, INC.

1. Vehicle Identification

1.1	Test No. 1	1A
1.2	Car No. 2	205
1.3	License No.	ZZT 088
1.4	Inspected By	JH
1.5	Date	6-24-71

2. Ignition System Inspection

		Measurement or Analysis		Manufacturer's Specification	
2.1	Required Voltage, kv at 1500 rpm	3 5-8	kv	4	kv
2.2	Coil Available Voltage, kv at 1500 rpm	5 36	kv	6	kv
2.3	Spark Line (OK, NG)	7 NG			
2.4	Coil Oscillations (OK, NG)	8 NG			
2.5	Point Opening Variation, degrees	9 2	°		
2.6	Coil Polarity (OK, NG)	10 OK			
2.7	Ignition Point Dwell, degrees	11 35	°	12 27-32	°
2.8	Condenser Oscillations (OK, NG)	13 OK			
2.9	Basic Ignition Timing, degrees	14 10 BTDC	°	15 5° BTDC	°
2.10	Total Advance at 2500 rpm, degrees	16 50	°	17 41-50 1/2	°
2.11	Mechanical Advance, at 2500 rpm, degrees	18 28	°	19 23-26 1/2	°
2.12	Vacuum Advance at 2500 rpm, degrees	20 22	°	21 18-24	°

3. Induction System

REL

3.1	Idle Speed, rpm (Chrys. in Neutral) NX Dr	1 650	rpm	2 600	rpm
3.2	Manifold Vacuum, in. Hg.	3 15	"	4	"
3.3	Air Cleaner Angle, degrees	5 0	°	6	°
3.4	Float Level, inches*	7	"	8	"
3.5	Choke, Vacuum Kick, inches	9 .081	"	10 .081	"
3.6	Choke Vacuum Diaphragm (OK, NG, None)	11 OK			
3.7	Heat Riser Valve (None, Free, Frozen)	12 FREE			

* On parking lot survey only

Figure 4.1 Engine Parameter Inspection Summary

		Measurement or Analysis		Manufacturer's Specification
4.	Emission Control			
	4.1 PCV Perf. at Idle, inches H_2O**	13 -.1	"	
	4.2 Vacuum Leaks (Yes or No)	14 NO		
	4.3 Idle rpm change (Leaks Eliminated)	15	rpm	
	4.4 NO_x Control Device (Ok, NG, None)	16 NONE		
	4.5 Timing Retard Mechanism (OK, NG, None)	17 NONE	REL	
5.	Keymode Diagnostic Inspection			

Dyno Load Set to 30 HP at 50 MPH

5.1 49/45 MPH Cruise

o Plug Req'd Volt, kv	1	7-9	kv
o Misfire Rate, %	2	0	%
o Air Cleaner Restriction, in H_2O	3	.2	"
o PCV Flow, inches	4	.40	"
o Air Pump Disconnected, Emissions			

Completed By _____

5.2 33.5/30 MPH Cruise

o Plug Req'd Volt, kv	5	8-10	kv
o Misfire Rate, %	6	0	%
o Air Cleaner Restriction, in H_2O	7	.1	"
o PCV Flow, inches	8	.40	"
o Air Pump Disconnected, Emissions			

Completed By _____

5.3 Idle (in Drive)

o Plug Req'd Volt, kv	9	12-15	kv
o Misfire Rate, %	10	0	% REL
o Air Pump Disconnected, Emissions			

Completed By _____

REMARKS: .High point resistance

** Vacuum is minus (-), and Pressure is plus (+)

Figure 4.1 Engine Parameter Inspection Summary (Cont'd)

introduction of malfunctions called for in the experimental program design.

4.2 PARAMETER MALFUNCTION METHODS

All parameter deviations from manufacturer's specifications are shown in Figure 3.1. Deviations of idle rpm, idle CO, and timing advance were adjusted using standard shop ignition analyzers and standard NDIR instrumentation for idle CO settings. Methods for achieving all other malfunctions are shown in Figure 4.2. Confounding malfunctions were introduced in the two emission fleet vehicles to create the possibility of errors of omission and commission by the service organizations. The confounding parameters were a bent push rod (which simulated valve failure), which could be confused with misfire, and a high carburetor float level which would produce a high CO reading under light and heavy load conditions, and could be confused with a malfunctioning PCV valve or restricted air cleaner element.

The measure of air cleaner deviation from specification used on this program was the volume % CO increase over that produced using a baseline air cleaner element measured at 50 mph road load. If an increase of 2.5% CO at 50 mph road load could not be obtained before a maximum AC air cleaner tester reading of 180^{o} was observed, the restriction was limited to that which produced this maximum indicated value. This is the same procedure employed on the orthogonal experiments for indicating the degree of element restriction. Idle CO was set for each experiment using standard NDIR instrumentation.

After the vehicle was malfunctioned for the first time, it was run on a Clayton key mode cycle to establish an emission baseline. This provided a baseline from which to detect incorrect maintenance or unwanted carburetor repairs. Modified, Clayton key mode truth charts were also prepared from these data.

4.3 SERVICE ORGANIZATION SELECTION

Three classes of service organizations were selected for the experiment: franchised dealerships of major American automobile manufacturers, independent garages, and major oil company service stations. The three

Figure 4.2

Malfunction Methods

NO_x Control

Transmission controlled spark relay points bent open, shorted thermal switch, transmission controlled spark fuse blown, speed switch lead disconnected.

Spark Plug Wire

Hole in insulation near ground, removed conductor from insulation, wire disconnected.

Spark Plug

Tight gap, carbon resistor removed from plug, center electrode removed.

Air Cleaner

Restricted with shellac, "Dressed up" with oil film and dust to look realistic.

PCV Valve

Plugged with devcon, "Dressed up" with oil and dust to look realistic.

Heat Riser

Wired Open, bind shaft with soft tubing or wire.

classes were chosen to evaluate their relative performance capabilities.

The experiment was conducted in two geographic locations: San Bernardino and Riverside, California. Selection of repair agencies were made as follows: A list of organizations which were registered as California Class A service organizations was obtained from the California Highway Patrol Office, (the Agency responsible for issuing license for Class A service organizations and policing their performance). Service organizations were then selected at random as candidates for participating in the program. The method of soliciting participation is discussed in paragraph 4.4.

4.4 INTERFACE WITH SERVICE ORGANIZATIONS

A personal contact was made with service organizations selected as candidates to determine their interest in performing maintenance work for Scott and their ability to process the vehicles in a timely fashion. Since Scott's involvement in air pollution research is known locally, the service organizations were informed that a group of vehicles used on several emission test programs required maintenance in order to qualify for a California Smog Certificate. It was stated that Scott had made the inspections which indicated the need for maintenance but did not have sufficient personnel to perform the maintenance. Scott also was not licensed to issue Smog Certificates. This approach minimized the possibility that the service organizations would infer that the California Highway Patrol was using this method to audit their performance. When this question occasionally arose, Scott replied, as was true, that the Highway Patrol was not involved in any way with this test program.

The initial plan was to send both the parameter inspection vehicles and the emission inspection vehicles to the same set of dealerships for repair. As the program developed, it became obvious that such a plan would cause too much discussion with service organizations, since the instructions were different for each fleet of five (5) vehicles. This part of the plan was therefore changed so that only parameter vehicles or emission vehicles were sent to a single service organization. The problems encountered are discussed more fully in Section 5.4.

4.5 TEST PROGRAM DESCRIPTION

4.5.1 Test Plan

The test plan called for two groups of vehicles, a five (5) vehicle parameter inspection fleet and a five (5) vehicle emission inspection fleet. Each fleet was to be submitted to five (5) dealerships, five (5) service stations and five (5) independent garages in the San Bernardino area and in the Los Angeles area. This would have resulted in a total of one hundred and fifty (150) tests on the two fleets of vehicles in each geographical area for a total of three hundred (300) tests.

This goal was not achieved for the following reasons:

a) The time required for vehicle processing by the service organizations was longer than planned and the total time required to complete the program would have extended beyond the contract period.

b) The combination of higher repair costs than anticipated, and the increased cost to lease vehicles for a longer performance period, resulted in higher program costs than had been planned.

c) A cost trade-off between conducting the tests in Los Angeles or Riverside showed that more data could be obtained by selecting Riverside as the second geographical location to be investigated. The same cost study showed that the number of tests in Riverside needed to be set at thirty (30) emission fleet tests and sixty (60) parameter fleet tests in order to meet contract cost constraints. Thus, ninety (90) tests were conducted in Riverside instead of the originally planned one hundred and fifty (150) tests in Los Angeles as the second geographic location. The lower number of tests, however, were sufficient to determine if geographical location had a significant effect on maintenance accuracy and cost.

4.5.2 Vehicle Set-up and Check After Service Organization Maintenance

The ten test vehicles were precisely maladjusted to the degree specified in Table 3.1 prior to submittal to each service organization.

Also, each vehicle received the same set of malfunctions each time it was submitted to a service organization.

After a vehicle was malfunctioned in preparation for submittal to the first repair agency, it was tested on the Clayton Key Mode Cycle to establish the emission baseline and to record the "standard" malfunction deviations to be used throughout the test program. Figure 4.3, Service Organization Evaluation Inspection Sheet, shows an example of the Scott inspection sheet used to record the vehicle malfunction settings made before submitting a vehicle for maintenance and the record of settings made by the service organization. This inspection sheet was used to insure consistent malfunction settings for each vehicle by Scott mechanics as well as to record settings and repairs made by each service organization.

After test vehicles were returned to Scott, they were inspected by Scott mechanics to determine how effectively the service organization had performed. The Service Organization Evaluation Inspection Sheet, Figure 4.3, illustrates how garage performance was evaluated.

- The "malfunction specification" entries are the required settings and malfunctions to be made by Scott prior to submittal to the service organization.
- The "settings achieved" entries are the actual settings made by Scott prior to submitting the car to the service organization.
- "Settings after repair" are the engine parameter settings or malfunctions determined by Scott after the vehicle was returned by the service organization. Under the headline "comments", if the Scott mechanic detected evidence that an item such as the carburetor had been overhauled, this note would flag the project engineer to check the repair invoice, and if indeed there was documented carburetor repair kit costs and labor, the vehicle would be returned and reset to the "malfunction specification" condition, as described in paragraph 4.5.5.
- If no unwarranted work was performed, the vehicle was reset to the required "malfunction specification", condition in preparation for submittal to another service organization.

All malfunctioned vehicles were sent to service organizations with a request to perform the maintenance necessary to issue a California Smog Certificate. The specific data accompanying the parameter inspection and emission inspection vehicles are described in paragraph 4.5.2. In addition

Figure 4.3

Service Organization Evaluation
Inspection Sheet

Car Number and Description 1971 Ford LTD Service Organization Welstand's Mid-Nite Auto

	Idle		Timing		Misfire		Induction System		Choke System	
	% CO	rpm	Basic	NO_x Control	Plug Wire	Spark Plug	Air Cleaner % CO	PCV	Heat Riser	Blade Setting
Malfunction Specification	4.4	575	16 BTOC			6%	0.2%	OK	Free	.19 in.
Setting Achieved	4.4	575	16			6%	180°	OK	Free	.19 in.
Setting After Repair	0.7	625	6			0	0°	OK	Free	.19 in.

Inspected by and Date JOHN DOE 11/1/71

COMMENTS

1) THERE IS EVIDENCE THAT THE CARBURETOR HAS BEEN OVER HAULED

to the specific instructions supplied for both fleets limitations were imposed on the repair organizations requiring prior approval for major work such as valve jobs and carburetor rebuilding. This is consistent with normal practice in California where individuals request the opportunity to review the cost of major repairs prior to initiating the work. If an organization reported that they could not issue a smog certificate without major work, Scott recalled the vehicle, with the explanation that customer approval was required for maintenance of that magnitude. If a repair invoice indicated that non-required work had been performed on a carburetor and an emission upset was produced, the carburetor was returned as nearly as possible to its original state. The original keymode inspection was then repeated to establish a new emission baseline.

4.5.3 Parameter Inspection Fleet

A simple instruction sheet, Figure 4.4 Typical Malfunctions Which Cause High Exhaust Emissions, was given to the service organization with vehicles of the parameter inspection fleet along with a request to perform the repairs necessary to provide a smog certificate. As can be noted, the instructions were very general. They included the written approval clause, and requested that the service organization record the settings used for adjusting idle speed, idle mixture, basic timing and choke kick. These data were requested to determine if the mechanic making the repair had used correct manufacturer's specifications.

4.5.4 Emission Inspection Fleet

The emission inspection vehicles were given to service organizations together with instructions similar to the Clayton Truth Charts, Figures 4.5 through 4.12. Only those truth charts applicable to the emission tests failed by the vehicle were sent with the vehicle. It was presumed that this practice would be followed in an actual mandatory program of inspection and maintenance which employed a mode emission inspection.

As with the parameter inspection vehicles, major repairs were not permitted without prior approval and requests for conducting major repair were handled in the same manner. Again it was requested that the service organization record the settings used to adjust engine parameters. The same control sheet, Figure 4.3 was used to record vehicle settings after repair.

Figure 4.4

TYPICAL MALFUNCTIONS
WHICH CAUSE HIGH EXHAUST EMISSIONS

Please check and set to Factory Specifications or Replace Parts as Necessary.

	Please Record Setting Used
1. Idle Speed	_____
2. Idle Mixture	_____
3. Basic Timing	_____
4. Choke Blade (1)	_____
5. Ignition Misfire	
6. Air Cleaner	
7. PCV Valve	
8. Exhaust Heat Valve	
9. Oxides of Nitrogen (NO_x Control) System (2)	

NOTE: Written Approval will be Required for All Major Work Such As:

1. New carburetors or "boil outs"
2. New distributors
3. Head & intake gaskets
4. Valve grinding
5. Engine overhaul

(1) Choke Blade Nomenclature

1. Vacuum kick or break
2. Choke valve pull-down
3. Initial choke opening
4. Intermediate choke rod - piston choke

(2) NO_x Control Nomenclature

1. A.M.C. and G.M. - Transmission Controller Spark (TCS)
2. Chrysler Corp. - NO_x System

Figure 4.5
TRUTH CHART #1
High HC @ Idle Only

Usual Causes

1. Vacuum leaks
2. Idle too lean or jets not balanced
3. Timing advanced grossly
4. Intermittent misfire
5. Low idle speed
6. Bad exhaust valves

Authorized Repairs if Out of Specification

1. Check dwell, timing, idle speed, and mixture
2. Check spark plug gaps

PLEASE RECORD SETTING USED IF ANY OF THE FOLLOWING ARE ADJUSTED

IDLE SPEED_____

IDLE MIXTURE_____

BASIC TIMING_____

Figure 4.6

TRUTH CHART #2

High HC @ Idle and at Low Cruise

Usual Causes

1. Vacuum leaks
2. Idle too lean or idle jets not balanced
3. Timing advanced grossly
4. Bad exhaust valves
5. Excessively rich mixture (high CO)
6. Ignition misfire

Authorized Repairs if out of Specification

1. Check dwell, timing, idle speed and mixture
2. Make oscilloscope checkout
3. Check spark plug gaps

PLEASE RECORD SETTING USED IF ANY OF THE FOLLOWING ARE ADJUSTED

IDLE SPEED_____

IDLE MIXTURE_____

BASIC TIMING_____

Figure 4.7

TRUTH CHART #3

High HC @ Low and/or High Cruise

Usual Causes

1. Ignition misfire, usually in secondary
2. Faulty distributor, causing over advance

Authorized Repairs if out of Specification

1. Check dwell and timing
2. Use an oscilloscope to check
   a. faulty spark plug
   b. faulty ignition cable
   c. loose primary wiring
   d. point arcing
   e. cross fire due to cracked or carbon tracked cap or rotor
   f. corrosion in distributor cap or wires not seated

PLEASE RECORD SETTING USED IF ANY OF
THE FOLLOWING ARE ADJUSTED

IDLE SPEED_____

IDLE MIXTURE_____

BASIC TIMING_____

Figure 4.8

TRUTH CHART #4

High HC in all Modes

Usual Causes

1. Disconnected ignition wire
2. Completely fouled spark plug
3. Secondary wiring defective
4. Faulty distributor
5. Bad valves

Authorized Repairs if out of Specification

1. Check dwell and timing
2. Use an oscilloscope to check
   a. faulty spark plug
   b. faulty ignition cable
   c. loose primary wiring
   d. point arcing
   e. cross fire due to cracked or carbon tracked cap or rotor
   f. corrosion in distributor cap or wires not seated

PLEASE RECORD SETTING USED IF ANY OF THE FOLLOWING ARE ADJUSTED

IDLE SPEED_____

IDLE MIXTURE_____

BASIC TIMING_____

Figure 4.9

TRUTH CHART #5

High CO @ Idle

Usual Causes

1. Maladjusted idle jets
2. Carburetor leaking internally

Authorized Repairs if out of Specification

1. Adjust carburetor mixture and speed

PLEASE RECORD SETTING USED IF ANY OF THE FOLLOWING ARE ADJUSTED

IDLE SPEED_____

IDLE MIXTURE_____

BASIC TIMING_____

Figure 4.10

TRUTH CHART #6

High CO @ Idle and at Low Cruise

Usual Causes

1. Severely maladjusted idle jets
2. Restricted PCV
3. Choke blade partially closed
4. High float level
5. Internal carburetor leaks

Authorized Repairs if out of Specification

1. Check PCV system
2. Check choke blade
3. Set dwell, timing, idle speed and mixture

PLEASE RECORD SETTING USED IF ANY OF THE FOLLOWING ARE ADJUSTED

IDLE SPEED_____

IDLE MIXTURE_____

BASIC TIMING_____

Figure 4.11

TRUTH CHART #7

High CO @ Low Cruise and/or High Cruise

Usual Causes

1. Malfunction in carburetor main metering system
2. High float level
3. PCV restriction
4. Air cleaner restriction
5. Choke blade partially closed

Authorized Repairs if out of Specification

1. Check PCV system
2. Check air cleaner
3. Check choke blade

PLEASE RECORD SETTING USED IF ANY OF THE FOLLOWING ARE ADJUSTED

IDLE SPEED_____

IDLE MIXTURE_____

BASIC TIMING_____

Figure 4.12

TRUTH CHART #8

High CO in all Modes of Operation

Usual Causes

1. A substantial internal leak in carburetor
2. A combination of malfunctioning carburetor main system and maladjusted idle jets

Authorized Repairs if out of Specification

1. Check for air cleaner restriction
2. Check choke plate for being stuck partially closed
3. Set ignition timing, dwell, idle speed and mixture

PLEASE RECORD SETTING USED IF ANY OF THE FOLLOWING ARE ADJUSTED

IDLE SPEED_____

IDLE MIXTURE_____

BASIC TIMING_____

4.5.5 Service Organization Maintenance Evaluation

Each service organization was requested to provide a detailed repair invoice indicating parts and labor. The Service Organization Evaluation Inspection Sheet, Figure 4.4 repair invoices, and the manufacturer's baseline parameter data were collected by the project engineer for each test of each vehicle. All pertinent data were tabulated by vehicle number, test number and service organization type and location. These data were analyzed, as discussed in Experimental Results (Section 5), to determine maintenance effectiveness, i.e., how many malfunctions were detected and properly maintained, and the maintenance cost. An attempt was also made to determine the extent of unnecessary maintenance performed on each vehicle. This was done by reviewing the repair invoices to find unnecessary parts or labor descriptions and the mechanics notes on the inspection form, Figure 4.3.

All organizations did not provide detailed cost invoices showing all parts and labor. Thus the estimates of unnecessary maintenance were subject to errors in judgement when data were not provided. This is discussed in more detail in Section 5.0, Experimental Results.

4.5.6 Experimental Difficulties

4.5.6.1 Typical Difficulties

Several types of experimental difficulties were encountered during the test program.

a) Malfunction Selection

During approximately the first two weeks of the program, the malfunction matrix (Figure 3.1a) contained malfunctions which were not completely consistent with vehicle mileage or age, (particularly the 1970 and 1971 models). In the initial matrix, PCV valves were failed on some late model cars when submitted to the repair agencies. The frequency of misfire and NO_x control component failure also were not consistant with service organization experience. This resulted in calls from the service organizations concerning the malfunctions. In some cases, the caller asked whether the California Highway Patrol was using this method to audit their work. In other instances, the questions indicated disbelief that specific malfunctions were natural.

Scott and TRW reviewed the malfunction matrix and either eliminated those malfunctions which had been questioned most frequently or revised them to represent natural malfunctions more closely. Enough malfunctions per vehicle were kept to produce sufficient data for subsequent statistical analyses.

The revised malfunction matrix, Figure 3.1, and the explanation that the vehicles had been used on a variety of experimental programs which might have resulted in a higher incidence of failures, reduced the telephone calls primarily to questions concerning the need for major maintenance. Since the questionable malfunctions were eliminated early in the program, the results of the experiment are considered to be valid.

b) Requests For Major Overhaul Authority

Occasionally, a service organization would request permission to perform a valve grinding job (caused by the indicated valve failure due to the bent push rod), or to rebuild or replace a carburetor. Usually, the request was accompanied by the statement that unless the work was authorized, the service organization could not issue a California Smog Certificate. In these instances Scott recalled the vehicle with the explanation that the Sponsor's permission would be required to authorize major repair.

Since Scott could not determine what maintenance had been done prior to the recall, these tests were not used in the evaluation of the maintenance effectivenss of service organizations.

4.5.6.2 Experimental Difficulty Effects on Program

Even though experimental difficulties did occur, the kinds of difficulties encountered in the experiment would tend to result in better rather than less effective maintenance performance by the service organizations. The experiment therefore may overestimate the effectiveness with which maintenance is performed by the spectrum of service organizations studied.

5.0 RESULTS

The analysis of the data acquired in the previously described test program was conducted in two steps:

- An engineering evaluation of the data was performed to select a procedure for systematically analyzing its details.
- Statistical analyses were done to separate real effects from experimental variability.

These two steps are described in detail in the following discussion.

5.1 OVERVIEW

An examination of the data indicated that the performance effectiveness of all the types of service organizations tested was marginal to poor for vehicles in both the parameter inspection and emission inspection fleets. A top level summary of the fraction of malfunctions and maladjustments corrected by each class of service organization is presented in Table 5.1. The data shown were obtained by pooling test results obtained in the San Bernardino and Riverside areas. This table shows that up to 52 percent of the emissions related malfunctions and maladjustments remained uncorrected following maintenance. Successful maintenance performance ranged from 48 to 68 percent. These data further suggest that some types of service organizations perform better than others. This point will be explored in a following section of this report.

Table 5.2 which shows the range of detection and the range of successful repair of engine malfunctions indicates that the detection of a malfunction does not guarantee a successful repair. Again the data of this table were obtained by pooling the San Bernardino and Riverside test results. As shown, the detection rate for an idle fuel-to-air ratio maladjustment ranged from 55 percent to 100 percent while the ability of the service organizations to adjust this parameter to within ± 1 percent of manufacturers specifications ranged from complete failure to a maximum of 52 percent. Similar discrepancies between maladjustment detection and repair can also be seen for idle rpm, timing and choke kick. Detection

Table 5.1

Malfunctions Detected and Corrected

	Independent Garages		Dealerships		Service Stations	
	Emission Vehicles	Parameter Vehicles	Emission Vehicles	Parameter Vehicles	Emission Vehicles	Parameter Vehicles
Total Malfunctions Submitted	133	242	134	239	140	243
Malfunctions Found And Corrected	73	122	92	120	85	119
Malfunctions Not Corrected	60	120	42	119	55	124
% Malfunctions Found And Corrected	54%	50%	68%	50%	60%	48%

Table 5.2

Range of Detection or Repair
of Malfunctioned Parameters for
All Vehicles Under All Experimental Conditions

Parameter	Detection, %	Repair, %	Repair Type
Idle CO	55 to 100	0 to 52	Adjustment
Idle RPM	67 to 100	45 to 73	"
Basic Timing	50 to 89	33 to 78	"
NO_x Control Device	12 to 41	12 to 41	Parts Replacement
Spark Plug Wire Misfire	25 to 100	25 to 100	Parts Repair or Replacement
Spark Plug Misfire	50 to 96	50 to 96	Parts Replacement
Air Cleaner	67 to 86	67 to 86	"
PCV Valve	50 to 90	50 to 90	"
Heat Riser Valve	15 to 67	15 to 67	Parts Repair
Choke Kick	27 to 37	15 to 18	Adjustment

and repair percentages were identical for the other malfunctions studied because the repair generally entailed the replacement of a faulty part rather than an adjustment to specification.

5.2 IDLE ADJUSTMENT REPAIR ACCURACY

The three engine idle adjustments, idle CO, idle rpm and basic timing are continuous variables in that they can be set to an infinite number of values. The settings achieved during maintenance are influenced by equipment accuracy, human error, as well as errors in specification values and procedures. Table 5.3 shows the percent of maintained vehicles which were set within a given tolerance band about specification.

5.2.1 Idle CO

Idle CO adjustment accuracy is seen to be generally poorer than idle rpm and timing. There are several possible reasons for this poorer performance: 1) many service organizations use conventional fuel-to-air ratio meters instead of exhaust CO analyzers. This can result in both random and bias errors relative to values measured with the referee instrument. 2) idle CO can vary depending upon engine operating history immediately prior to measuring CO level. Referee measurements were made after the vehicles were driven back from the service organization and were not made following an extended period of engine operation at idle speed. 3) different sources may have been used to obtain vehicle adjustment specifications. For example, the certificate of compliance instructions specify a fuel-to-air ratio mixture between 13.5:1 and 14.5:1 which is on the rich side of most manufacturers' specifications.

5.2.2 Idle rpm and Timing

Although the maintenance effectiveness for idle rpm and basic timing was somewhat higher than for idle CO, it was still poor in many cases. These two adjustments are not as sensitive to prior vehicle operating conditions as idle CO. There are several possible reasons however for the variability found in their adjustment accuracy: 1) out of calibration tachometers; 2) inadequate or inconsistently applied procedures; and 3) obsolete, incorrect or misinterpreted tune-up specifications.

Table 5.3

Repair Accuracy
(% of Vehicles Within Specification Tolerance Limits)

	Independent				Dealerships				Service Stations			
	Emission Vehicle		Parameter Vehicle		Emission Vehicle		Parameter Vehicle		Emission Vehicle		Parameter Vehicle	
	San Bernardino	Riverside	San Bernardino	Riverside	San Bernardino	Riverside	San Bernardino	Riverside	San Bernardino	Riverside	San Bernardino	Riverside
Idle CO (1)	26%	13%	50%	44%	43%	63%	50%	60%	37%	13%	45%	31%
Idle RPM (2)	50%	80%	71%	65%	54%	67%	68%	53%	60%	33%	44%	65%
Basic Timing (3)	63%	44%	58%	70%	70%	80%	76%	68%	56%	70%	52%	45%

(1) Within 1% of Factory Specification

(2) Within ±50 rpm for Factory Specification

(3) Within 2° of Factory Specification

As described previously, service organizations were requested to record the specifications used for setting idle CO, rpm and timing to determine if the proper specifications were used. There is an indication that some service organizations may not have used proper specifications for making these adjustments. Table 5.4 shows the percent of times the service organizations achieved the timing and rpm settings they defined as specification values as compared to the standard specifications used for the program. The fact that service organizations frequently achieved adjustments closer to their reported specification values than to the referee values is not statistically conclusive, but is indicative of somewhat better performance than otherwise measured.

Table 5.4 also shows another interesting fact. Vehicles submitted to service organizations with their timing (vehicle #2 and 3) and rpm (vehicles #1, 4, 5, 6, 7 and 8) adjustments within specification were frequently returned out of specification. The raw data, Appendix A, indicate that idle rpm was generally set lower than specification and that basic timing was more often set advanced of the specification value than in a retarded condition. Because idle speed specifications for older vehicles are generally slower than for new vehicles the data may indicate that mechanics use their past experience in setting idle rpm and do not refer to new specifications. Dealerships may have performed better in making idle CO and idle rpm adjustments because their mechanics received more training than those of other service organizations in adjusting emissions related tune-up parameters.

It is noted that a possible confounding influence on this experiment may have been introduced by requesting that the service organizations provide a smog certificate for each car repaired. The California Highway Patrol Handbook for Installation and Inspection Stations under which the smog certificate is issued provides specific tolerance limits on timing and idle speed deviations from manufacturer's specifications. These instructions allow timing deviations of $\pm 3°$ from manufacturer's specifications while $\pm 2°$ was used as a performance standard in this study. Further, the California Highway Patrol Handbook allows an idle speed deviation of +100 rpm or -25 rpm from specifications while ± 50 rpm was used on this program. Because the service organizations tested would certainly have

Table 5.4

VARIATION OF REPAIR PERCENTAGE BASED UPON DIFFERENT REFERENCE SPECIFICATIONS

CAR NO.	BASIC TIMING				IDLE RPM			
	TOTAL NO.**	ADJUSTMENT TO SPEC.			TOTAL NO. **	ADJUSTMENT TO SPEC.		
		GARAGE SPEC.		SRL SPEC.		GARAGE SPEC.		SRL SPEC.
		NO.	%	%		NO.	%	%
1	19	12	63.2*	52.4*	18	14	77.8	66.6
2	12	9	75.0	70.0	11	5	45.5*	45.0*
3	17	16	94.1	100.0	19	10	52.6*	66.7*
4	16	12	75.0*	47.6*	16	7	43.8	47.7
5	13	8	61.5*	33.3*	14	7	50.0	55.6
6	26	15	57.7*	61.5*	25	11	44.0	30.8
7	25	22	88.0*	77.8*	26	15	57.8	63.0
8	25	13	69.2*	40.7*	26	18	69.2	70.4
9	26	18	69.3*	66.7*	27	21	77.8*	70.4*
10	23	15	65.2*	65.4*	23	15	65.2*	73.1*

*Parameters were malfunctioned when submitted to service organization.

**Total number of vehicle submittals to Service Organizations with timing and RPM adjusted outside of specification limits ($\pm 2°$ timing ± 50 RPM)

had access to this handbook, it is possible that their performance was influenced by its less restrictive tolerance bands on engine adjustments.

5.3 COMPONENT REPAIR ACCURACY

Some of the simulated malfunctions involve components which either operate satisfactorily or are failed. These malfunctions therefore are considered to be discontinuous or bimodal variables. If this class of malfunction is detected then it generally can be completely corrected by parts repair or replacement. Table 5.5 shows the percentage of malfunctions within this class which were detected and repaired. The indicated maintenance effectiveness for spark plug misfire (90%), plug wire misfire (79%), PCV valve failures (77%), and excessive air cleaner plugging (74%) was fairly good while that for failed heat riser valves (36%) and NO_x control device failure (21%) was poor.

The choke blade relief sitting is the only continuous variable studied other than the idle adjustments previously discussed. The service organizations tested showed very poor (17%) ability to detect and repair this maladjustment which has a pronounced effect upon engine cold start emissions.

There are several possible reasons for the observed variation in maintenance effectiveness. Diagnosis of misfire due to malfunctioned spark plugs or the ignition wire harness (spark plug wire) is a common procedure. PCV valves have been installed in California vehicles for several years and most mechanics are familiar with this device. Air cleaners can be visually inspected to see if they "look dirty." All of these components are usually carried in inventory and are readily replaceable. Thus, the high frequency of detection and repair may be a matter of familiarity with the diagnostic and repair procedures. Examination of the test data, Appendix A, shows that the frequency of diagnosis and repair of the PCV valve was highest for the older vehicles. A possible reason is that mechanics may <u>expect</u> to find a faulty PCV valve in older vehicles and their experience indicates that newer vehicles do not usually have faulty PCV valves.

Table 5.5

Repair Accuracy for Malfunctions
Requiring Repair or Replacement

Malfunction	Independents % Found		Dealerships % Found		Service Station % Found		Total % Found
	Emission	Parameter	Emission	Parameter	Emission	Parameter	
NO_x Device	0	19	57	34	14	7	21
Misfire (Plug Wire)	92	44	85	88	100	44	79
Misfire (Spark Plug)	100	88	100	100	71	83	90
A/C	64	88	78	61	85	66	74
PCV Valve	88	76	85	55	100	66	77
Heat Riser	42	23	71	33	85	16	36
Choke Blade Setting	--	6	--	22	--	22	17

The NO_x control device, however, is a relatively new component or system. The poor maintenance effectiveness measured is most likely due to a lack of familiarity with this new system. Dealership performance, although low, was better than either that of independent garages or service stations, probably because of their greater familiarity with new vehicle accessories.

Poorest maintenance performance was observed in the setting of carburetor choke blade kick angle. This may be caused by the fact that the choke blade is open during hot engine operation and the kick angle is not routinely checked unless either there is a starting complaint or the carburetor is overhauled. It should again be noted that specific approval was required before a carburetor overhaul could be performed on the test vehicles. This restriction may have discouraged the investigation of the choke blade relief setting.

5.4 REPAIR COSTS

Service organizations were requested to provide both parts and labor cost breakdowns for each repair order. These data however were obtained only in part. Many repair bills showed parts costs and labor costs, but did not provide a detailed separation of labor associated with each repair. Usually, the labor was billed as a lump sum. A precise analysis of the various cost elements therefore was not possible. An attempt was made however to characterize average costs and to identify repairs leading to excessive costs.

5.4.1 Average Repair Costs

Table 5.6 is a summary of the average costs grouped by inspection process, service organization, and city. It can be seen that average costs were highest for dealerships in both cities and were highest in Riverside for all types of service organizations. There was no significant difference in cost associated with instructions reflecting the two basic types of vehicle inspection strategies. Independent garages and service station costs exhibited differences between the two cities. Differing combinations of malfunctions certainly account for some of this. Difficulty in conducting the maintenance because of parts availability and malfunction accessibility varies with each vehicle and also may account for some part of the performance differences.

Table 5.6

Average Repair Costs ($)

	Independent Garages		Dealerships		Service Stations	
	Emission Vehicles	Parameter Vehicles	Emission Vehicles	Parameter Vehicles	Emission Vehicles	Parameter Vehicles
Average Cost to Repair Malfunctions:						
Riverside	14.87	36.99	33.68	28.97	29.49	11.07
San Bernardino	13.99	19.95	26.57	27.85	16.10	18.66
Highest Cost to Repair Malfunctions:						
Riverside	19.85	71.15	38.74	81.33	46.38	27.46
San Bernardino	33.95	49.08	57.61	42.39	31.89	26.32
Lowest Cost to Repair Malfunctions:						
Riverside	7.50	14.51	11.95	9.00	11.00	5.50
San Bernardino	5.00	7.00	1.42	7.29	4.60	6.50

5.4.2 Unnecessary Repairs

An estimate of unnecessary repairs was made from those invoices which provided a separation of costs. The true magnitude of unnecessary repair costs is still speculative because complete parts and labor breakdowns could not be obtained from all service organizations without compromising the blind nature of the experiment. The dollar values shown in Table 5.7 for unnecessary repairs reflects identifiable cost of unnecessary parts only. Even on this basis the average unnecessary repair cost in some service organizations exceeded $9 per car with one bill judged to contain $36 in unnecessary parts. If a one to one ratio is a reasonable estimate of labor to material costs then the cost of unnecessary repairs would be double those shown in Table 5.7.

The higher costs shown for unnecessary repairs made by dealerships is believed to reflect the fact that dealership invoices provided a more complete list of parts and hence provided a better means for identifying unnecessary repairs. Unnecessary repair costs in the other two types of service organizations therefore are probably underestimated.

A Summary of Unnecessary Repairs Performed, Table 5.8, reflects the estimated number of such repairs and identifies the types of repair considered unnecessary. The higher average cost of repair in Riverside appears to be highly correlated to excessive repair.

5.4.3 Vehicle Process Time

The average length of time required by service organizations to repair the test vehicles was 1.4 days. The importance of this information is that it is a measure of what mandatory inspection and maintenance programs will cost the public either in inconvenience or in vehicle rental costs when service organizations do not provide loan vehicles.

Table 5.7

Summary of Excessive Repair Costs
(Dollar Cost of Unrequired Parts Replacement)

	Independent Garages		Dealerships		Service Stations	
	Emission Vehicles	Parameter Vehicles	Emission Vehicles	Parameter Vehicles	Emission Vehicles	Parameter Vehicles
Average Unnecessary Repair Costs:						
Riverside	.45	9.01	9.46	4.43	9.53	.88
San Bernardino	.39	1.66	3.70	4.26	1.85	4.08
Highest Unnecessary Repair Costs:						
Riverside	4.05	26.55	36.81	21.53	24.23	7.14
San Bernardino	6.12	1.66	19.11	27.04	28.70	17.95

Table 5.8

Summary of Number of Unnecessary Repairs Performed

	Independents		Dealerships		Service Stations	
	Emission Vehicles	Parameter Vehicles	Emission Vehicles	Parameter Vehicles	Emission Vehicles	Parameter Vehicles
Number of Unnecessary Repairs Performed:						
Riverside	1	28	22	23	15	7
San Bernardino	2	9	18	21	11	18
Number of Unnecessary Repairs Performed Per Vehicle Processed:						
Riverside	.11	1.40	2.20	1.21	1.50	.35
San Bernardino	.08	.38	.78	.84	.44	.72

TYPICAL UNNECESSARY REPAIRS PERFORMED

1. Complete set of spark plugs or plug wires installed when only one was malfunctioning.
2. New PCV valve when not needed.
3. New air cleaner when not needed.
4. New vacuum hose when not needed.
5. New NO_x switch and control device when malfunctioned device could easily be repaired.
6. Gas or oil additives.
7. Tune-up components installed when not needed. (Points, condensor, rotor distributor cap).
8. Fuel filter
9. Vacuum advance unit; and vacuum brake.

5.5 STATISTICAL ANALYSIS

Statistical analyses were made of the experimental data to determine the influence on maintenance performance effectiveness of:

- Instruction given to the service organizations (parameter inspection or emission inspection data)
- Class of service organization
- Service organization location
- Vehicle and control device characteristics.

The deviation of idle CO, idle rpm and basic timing adjustments from specification as measured by Scott following repair was used as the dependent variable when analyzing performance. The total repair cost was used in making cost comparisons. With continuous variables such as idle CO, idle rpm, timing and cost where the number of measurements made at each experimental combination was not equal, an unweighted analysis of variance was employed.

For the other malfunctioned parameters, the category identification "found" or "not found" was the dependent variable. (For choke kick, the category identification "found and repaired" or "not repaired" was the dependent variable.) The number of malfunctions of a given type found and the number of malfunctions of that type not found was obtained for each city, each service organization type and for each instructional level. A X^2 statistic with Yates Correction for continuity was used when there were only two levels of the dependent variable.

Table 5.9 presents the results of these analyses and shows the confidence level ($Q \geq 0.9$) associated with the F statistic obtained for each treatment main effect on each dependent variable. This table indicates that for certain malfunctioned parameters, there was a significant influence of city, service organization type, inspection instructions and vehicle. As can be seen, vehicle effects are most predominant. The effects of service instruction are significant for idle CO, heat riser, and plug wire misfire. However, the partitioning of test vehicles by service instruction makes conclusions about service instruction effects tentative, at best. The partitioning of vehicles by service instructions does not, of course, affect conclusions about city or service organization effects. It should also be noted that the experiment is not symmetrical

Table 5.9

Results of Analyses of Variance Using the Complete Data Set (Confidence Levels ≥90)

Parameter	Cities Effect (2)	Service Organization Type Effect (3)	Service Instruction Effect (2)	Vehicle Effect (10)
Idle CO	.90	.95	.95	.99
Idle RPM	-	-	-	.99
Basic Timing	-	-	-	.99
Cost	.95	.99	-	.95
NO_x Control	-	.99	-	.99
Misfire (Plugwire)	-	-	.99	-
Misfire (Spark Plug)	-	.90	-	.98
Air Cleaner	-	-	-	-
P.C.V. Valve	-	-	-	-
Heat Riser	-	-	.99	-
Blade Setting	-	-	-	-

by the type of service instruction (i.e., similar model/year vehicles in each group did not have identical malfunctions) or city (i.e., sample sets of the two cities were different). The effect of non-symmetric sample sets between cities was accounted for by the method of analysis, however, conclusions regarding the type of service instruction are questionable.

The simultaneous occurrence of a significant vehicle effect and service instruction effect on idle CO makes the significant instruction effect obtained on idle CO questionable. Also, because the heat riser was malfunctioned in one older car in the emission inspection fleet, and in two newer cars in the parameter inspection fleet, it is likely that the significant instructional effect obtained should be attributed to a vehicle phenomenon. On the other hand, while there is vehicle confounding associated with the significant instructional effect on plug wire misfire, there is no obvious bias influencing the malfunction distributions of the two instructional groups. Therefore, we may tentatively conclude that the effect of service instruction is real for plug wire misfire.

5.5.1 Idle CO

The deviation of idle CO emission level after-repair relative to the established idle CO specification value was used as the dependent variable for this analysis. An unweighted means analysis of variance showed significant effects for the different cities ($F = 3.08$; $df = 1,174$; $Q > 0.90$), types of service organization ($F = 3.64$; $df = 2,174$; $Q > 0.95$), service instructions ($F = 6.00$; $df = 1,174$; $Q > 0.95$), and vehicles ($F = 14.31$; $df = 8,174$; $Q > 0.99$).

Table 5.10 shows mean idle CO deviation as a function of the city and type of service organization. San Bernardino service organizations showed better performance with the mean idle CO deviation for service organization in this city being smaller than in Riverside. The mean idle CO deviation was lowest in dealer service organizations, second lowest in independent garages and highest in service station.

Table 5.10

Mean, Post Maintenance Idle CO Deviation in Percent as a Function of City and Type of Service Organization

	Independent Garages	Dealerships	Service Stations	Mean
San Bernardino	0.605	0.306	0.637	0.516
Riverside	0.919	0.307	1.683	0.970
Mean	0.762	0.306	1.160	0.743

Table 5.11 shows the mean idle CO deviation as a function of vehicle and service instructions. The vehicle effect is grouped by the type of service instruction. It is clear from Table 5.11 that the mean idle CO deviation differs strongly by vehicle within each group. Table 5.11 also shows that the lower mean idle CO deviation achieved using emission inspection instructions is due largely to a negative value obtained for a single vehicle (1964 Chevrolet) and therefore, suggests that the significant instruction effect was really a vehicle effect.

The question arises as to what aspect of the vehicles was responsible for this highly significant effect. The mean idle CO deviation for each vehicle plotted as a function of the idle CO specification value for that vehicle is shown in Figure 5.2. The correlation between the idle CO deviations and the absolute value of idle CO specification is negative and significant ($r = -0.54$; $df = 232$; $Q > 0.99$). This relationship accounts for 29% of the variance in CO deviations. This correlation suggests that vehicle with lean idle specifications are not satisfactorily adjusted to specification with service organizations erroring in a direction to increase CO and HC exhaust emissions. Further, there is a tendency to over lean older vehicles. It would be significant in the implementation of an inspection program to determine whether this tendency is an equipment or procedural problem. The relationship between idle CO deviations and idle CO specification values explains more of the variance in after-repair measures than any of the other factors the study was designed to investigate.

Table 5.11

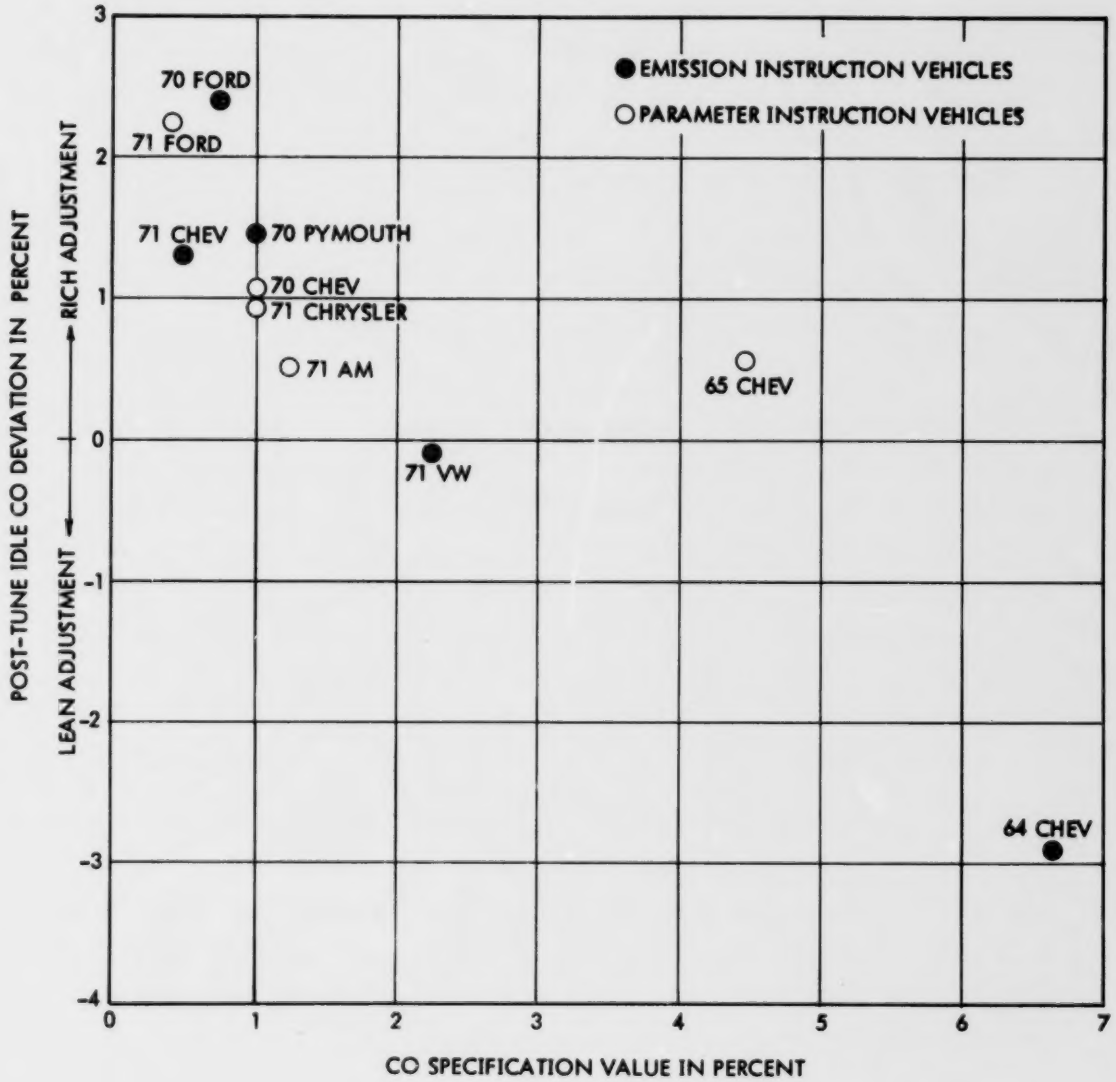
Mean Idle CO Deviation in Percent as a Function of Vehicle and Service Instructions

	Vehicle	%*
Emission Inspection Instructions	1964 Chevrolet	-2.919
	1970 Ford	2.412
	1971 Chevrolet	1.307
	1970 Plymouth	1.433
	1971 Volkswagen	-0.102
	Mean	0.426
Parameter Inspection Instructions	Vehicle	
	1971 Chrysler	0.946
	1965 Chevrolet	0.553
	1971 Ford	2.227
	1970 Chevrolet	1.066
	1971 American Motors	0.507
	Mean	1.060
	Overall Mean	0.743

*Deviation in idle fuel to air measured as percent CO. Positive values indicate fuel to air ratios which are rich relative to specification.

Figure 5.2

MEAN POST-TUNE IDLE CO DEVIATION AS A FUNCTION OF IDLE CO SPECIFICATION VALUE



5.5.2 RPM

The deviation of the after-repair idle RPM measured from specification (idle rpm deviation) was used as the dependent variable. An unweighted means analysis of variance showed a highly significant effect for vehicles ($F = 7.11$; $df = 8,174$; $Q \geq 0.99$) as well as significant interactions involving the vehicle and the variable. The service organization to vehicle interaction was significant ($F = 1.67$; $df = 16,174$; $Q > 0.90$) and the city to service organization vehicles interaction was significant ($F = 1.64$; $df = 16,174$; $Q > 0.90$). Both these interactions as well as the vehicle main effect were extracted from the data which was partitioned by the type of service instruction.

It is clear from Table 5.11 that mean post-tune idle rpm deviation differed across vehicles within each instruction type. Except for one vehicle, idle speed was consistently set below specification; a service error which increases HC emissions.

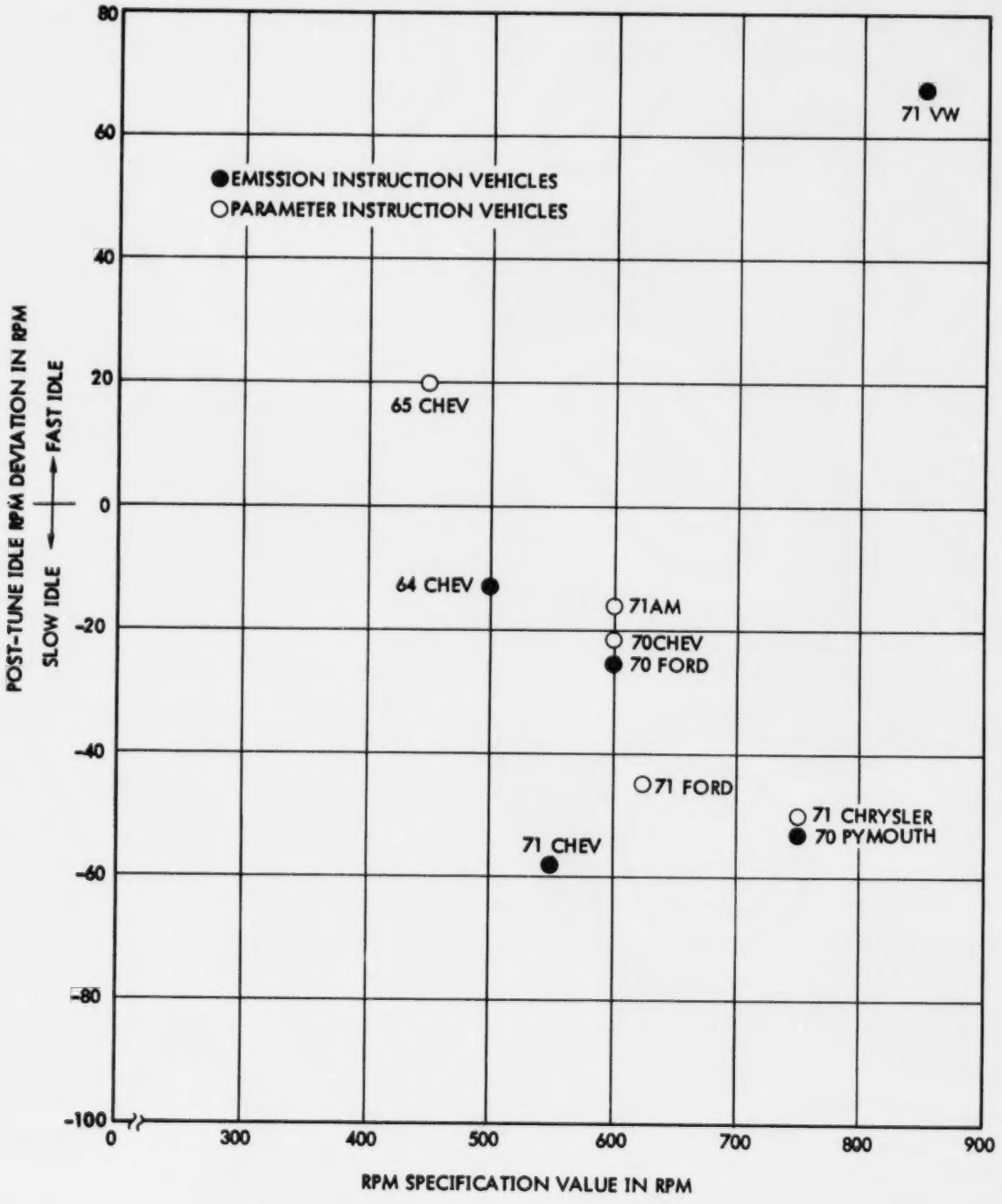
The mean post-tune idle rpm deviation for each vehicle was plotted as a function of its idle speed specification, Figure 5.3. With the notable exception of the VW, there is an inverse relationship between the post-tune idle rpm deviation and the idle rpm specification value. Omitting the VW data resulted in a significant, negative correlation ($r = -0.25$; $df = 214$; $Q > 0.99$) between post-tune rpm deviation and its specification value which accounts for 6.4% of the variance.

5.5.3 Timing

The deviation of the after-repair timing relative to specification (post-tune timing deviation) was used as the dependent variable. Advanced timing carries a positive sign; retarded timing a negative sign. An unweighted means analysis of variance showed a significant effect for vehicles only ($F = 5.08$; $df = 8,174$; $Q > 0.99$). The vehicle effect is partitioned by the type of service instruction.

Figure 5.3

MEAN POST TUNE IDLE RPM DEVIATION AS A FUNCTION OF IDLE RPM SPECIFICATION VALUE



It is clear from Table 5.14 that the mean post-tune timing deviation differed across vehicles. Timing, on the average, was set advanced of specification within each set partitioned by instruction type, except VW and American Motors vehicles. This error results in increased HC and NO emissions, but reduced CO emissions. The mean post-tune timing deviation for each vehicle was plotted as a function of the pre-tune deviation from timing specification, as shown in Figure 5.4. An interaction between service instructions and pre-tune timing deviation is indicated by the differences in slope between instructional type. The post-tune and pre-tune deviations were correlated without regard for instructional level. The correlation obtained ($r = 0.33$; $df = 232$; $Q > 0.98$) was significant and explains 10.9% of the total variation in timing deviations from specification.

Table 5.12

Mean Cost in Dollars as a Function of City and Type of Service Organization

	Independent Garages	Dealership	Service Stations	Mean
San Bernardino	16.97	27.21	17.38	20.52
Riverside	25.94	31.33	20.28	25.85
Mean	21.45	29.27	18.83	23.18

Figure 5.4

MEAN POST-TUNE TIMING DEVIATION (IN DEGREES) AS A FUNCTION OF PRE-TUNE TIMING DEVIATION (IN DEGREES)

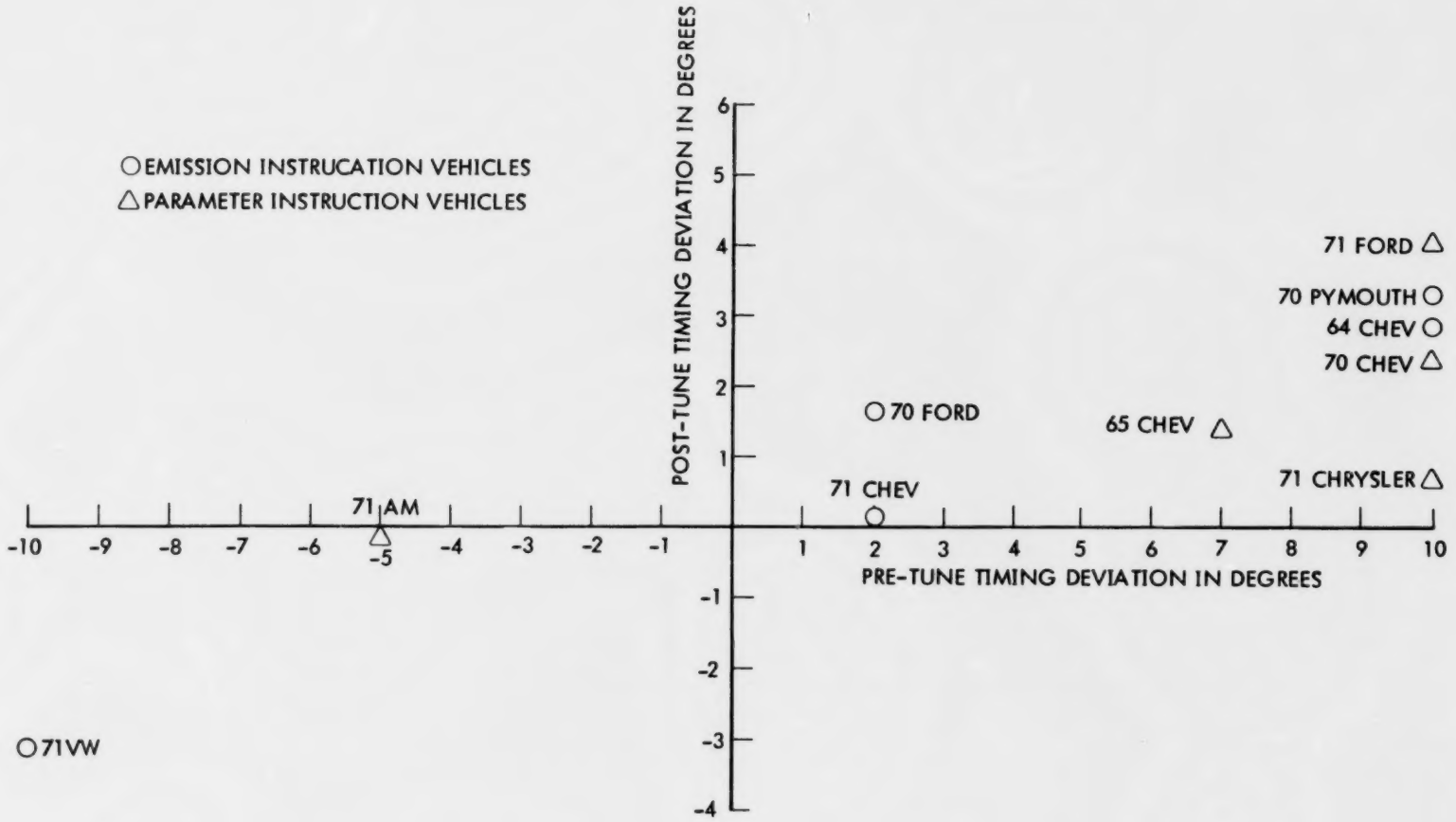


Table 5.13

Mean Idle Speed Deviation in RPM as a Function of Vehicle and Instructions

	Vehicle	Idle RPM *
Emission Inspection Instructions	1964 Chevrolet	-13.333
	1970 Ford	-25.583
	1971 Chevrolet	-58.250
	1970 Plymouth	-53.333
	1971 Volkswagen	-68.611
	Mean	-16.378
Emission Inspection Instructions	Vehicle	
	1971 Chrysler	-50.208
	1965 Chevrolet	19.792
	1971 Ford	-45.292
	1970 Chevrolet	-21.667
	1971 American Motors	-16.042
	Mean	-22.683
	Overall Mean	-19.530

*Deviation in idle speed measured as rpm, measured-specification, negative values are slow speed relative to specification.

Table 5.14

Mean Timing Deviation in Degrees as a Function of Vehicle and Service Instructions

	Vehicle	Degrees*
Emission Inspection Instructions	1964 Chevrolet	2.900
	1970 Ford	1.650
	1971 Chevrolet	0.117
	1970 Plymouth	3.367
	1971 Volkswagen	-3.167
	Mean	0.973
Parameter Inspection Instructions	Vehicle	
	1971 Chrysler	0.708
	1965 Chevrolet	1.417
	1971 Ford	4.033
	1970 Chevrolet	2.375
	1971 American Motors	-0.119
	Mean	1.683
	Overall Mean	1.328

*Deviation in basic timing measured in degrees. Positive values are advanced relative to specification.

5.5.4 NO_x Control and Spark Plug Misfire

There were significant service organization effects on NO_x control (χ^2 = 10.45; df = 2; Q >0.99) and on spark plug misfire repair (χ^2 = 5.54; df = 2; Q >0.90). The rank order of service organization repair effectiveness for both malfunctions as shown in Table 5.14 was found to be dealerships, independents and service stations. However, the level of repair effectiveness on spark plug misfire is uniformly superior (40 to 100%) to the level of repair effectiveness on NO_x control (9 to 40%). It is thought that the better relative performance of dealerships in correcting NO_x control malfunction results from their greater experience in handling new cars and their closer association through bulletins, etc., with the manufacturers.

There were not enough malfunction data for the emission instructions fleet to test for vehicle effects on NO_x repair and spark plug misfire repair. However, χ^2 tests were performed to determine vehicle effects on these two repairs in the parameter inspection fleet. There was a significant vehicle effect (χ^2 = 10.78; df = 2; Q >0.99) on NO_x repair as well as significant vehicle effect (χ^2 = 8.90; df = 2; Q >0.98) on spark plug misfire under parameter instructions. Table 5.15 shows that the NO_x control on the Chevrolets were more frequently repaired correctly than vehicles from the other two manufacturers.

Table 5.15

Percent of NO_x Control Device Replaced and Percent Misfire (Spark Plug) Corrected for the Three Types of Service Organizations

Type of Malfunction	Type of Service Organization		
	Independents	Dealerships	Service Stations
NO_x Control	15.1%	39.4%	8.8%
Misfire (Spark plug)	91.7%	100.0%	40.0%

Since Chevrolet is the only manufacturer with both 1970 and 1971 NO_x control devices in California, it is possible that repair agencies are more likely to inspect this component on Chevrolets because of more service exposure.

5.5.5 Misfire (Plug wire) and Heat Riser

The only significant effect on plug wire misfire repair performance was type of service instructions ($X^2 = 9.17$; df = 1; Q >0.99). The precent plug wire misfire corrected as a function of service organizations is given in Table 5.16. Plug wire misfire repair when given emission inspection instructions (93%) was superior to plug wire misfire repair performance for parameter inspection instructions (60%). Examination of the two sets of instructional materials indicates that the emission inspection instructions carried a more specific reference to the probability of a plug wire misfire malfunction than did the parameter inspection instructions and therefore performance would be expected to be better. Truth Chart #4, which accompanied the emission inspection vehicles, included among "usual causes" of "High HC in all modes" "Secondary wiring defective" and included among "Authorized Repairs If out of Specification" "Faulty ignition cable." The parameter inspection instructions listed "Ignition Misfire" as one of nine items to be checked.

The only significant effect on heat riser repair performance was the service instruction effect ($X^2 = 9.78$, df = 1; Q >0.99). Repair performance when given emission inspection instructions, Table 5.17, was superior to performance given parameter inspection instructions. This could and probably did result (as will be later discussed) from vehicle effects. The parameter inspection instructions were the only ones which specifically mention the heat riser valve. However, the California Highway Patrol Handbook for Installation and Inspection Stations, does indicate "heat valve not operating" as one of several causes of high exhaust emissions. Since the requirement to issue a Certificate of Compliance was implied in the general instructions for all vehicle repair, the two sets of instructions may not have had the different impact originally anticipated.

Table 5.16

Percent of NO_x Control Devices Replaced and Percent of Spark Plug Misfire Corrected on Vehicles Under Emission Instructions and on Vehicles Under Parameter Instructions

	Vehicles Under Emission Instructions	Vehicles Under Parameter Instructions		
	1971 Chevrolet	1971 Chrysler	1970 Chevrolet	1971 American Motors
NO_x	23.8%	7.7%	40.7%	11.5%

	Vehicles Under Emission Instructions	Vehicles Under Parameter Instructions		
	1971 Volkswagen	1965 Chevrolet	1971 Ford	1970 Chevrolet
Spark Plug Misfire	88.9%	50.0%	96.2%	91.3%

Table 5.17

Percent of Plug Wire Misfires Corrected as a Function of Service Instructions

	Instructions	
	Emission	Parameter
Plug Wire Misfire	92.7%	59.3%

The single emission inspection instruction vehicle with a malfunctioned heat riser valve was a 1964 Chevrolet, whereas the two vehicles in the parameter inspection fleet having this malfunction were a 1970 and a 1971 Chrysler. Service experience may have biased performance toward the other vehicle which would have a greater probability of a malfunctioned heat riser valve than the two newer cars. It is more probable that this is a vehicle effect rather than a difference in service instruction.

5.5.6 Air Cleaner, PCV Valve and Blade Setting

There were no significant effects for any of the independent variables (city, type of organization, instructions or vehicles) on the replacement of adjustment of air cleaners, PCV valves and blade settings. The percent of malfunctions corrected ranged from 73.9% for air cleaner to 76.9% for PCV valve. Service organizations are conditioned to replace these items since parts profit margins are high and labor cost is minimal. In contrast, their lack of familiarity with choke systems together with the requirement that the choke blade be inspected before engines have been warmed up probably explains the extremely poor performance (16.9%) in adjusting this parameter.

5.5.7 Cost

An unweighted means analysis of variance of repair costs showed significant effects for the two cities ($F = 6.11$; $df = 1,174$; $Q > 0.95$), service organizations ($F = 8.47$; $df = 2,174$; $Q > 0.95$), and vehicle ($F = 2.06$; $df = 8,174$; $Q > 0.95$). The service organization to service instructions interaction ($F = 9.21$; $df = 2,174$; $Q > 0.99$) and the city to service organization to instructions interaction ($F = 6.27$; $df = 2,174$; $Q > 0.99$) were also significant.

Table 5.18 shows service stations to have the lowest repair cost and the dealerships to have the highest. The average cost across all service organizations was higher in Riverside.

Table 5.18

Percent Heat Risers Adjusted
as a Function of Instructions

	Instructions	
	Emission	Parameter
Heat Riser	66.7%	24.5%

The higher dealership repair costs were first suspected to have resulted from the procedure used in San Bernardino of sending all vehicle makes to each manufacturers' dealerships. Lack of familiarity with other manufacturers' vehicles and unavailability of parts in inventory were suspected of increasing dealership repair costs. Therefore, in Riverside the procedure was changed to sending test vehicles to only the appropriate manufacturers' dealerships. Table 5.18 and the previously discussed analysis of variance still show a substantially higher average dealership repair cost in Riverside.

The variability of cost across vehicles partitioned by instruction type is also seen to be large, Table 5.19. On average, there is no substantial difference across instruction type. The vehicle effect is not too surprising since malfunctions were not identical across vehicles. An approximate indication of the level of vehicle malfunction is also indicated. Generally, "A" type maintenance consisting of idle parameter adjustments and component replacements in one of the major subsystems (ignition or induction) was required on most of the vehicles. The cost of repair is generally consistent with the degree of malfunction and the type of engine (4, 6 or 8 cylinder). "A" maintenance ranged in cost between 22 and 29 dollars, idle related maintenance, usually with one additional component replacement (I), ranged between 17 and 23 dollars. This cost level for idle adjustments, is higher than the 6 to 8 dollars quoted in a flat rate repair manual. However, it must be remembered that the repair instructions

Table 5.19

Mean Cost in Dollars as a Function of Vehicle and Service Instructions

	Vehicle	Degree of Malfunction	
Emission Inspection Instructions	1964 Chevrolet	A	$ 23.33
	1970 Ford	A	28.99
	1971 Chevrolet	I	17.30
	1970 Plymouth	I	23.48
	1971 Volkswagan	A	19.16
	Mean		22.45
Parameter Inspection Instructions	Vehicle		
	1971 Chrysler	A	21.71
	1965 Chevrolet	A	23.55
	1971 Ford	A	29.47
	1970 Chevrolet	B	28.31
	1971 American Motors	I	16.55
	Mean		23.92
	Overall Mean		$ 23.18

A = Idle adjustment plus component replacement in either the induction or ignition subsystems.

B = Idle adjustment plus component replacement in both induction and ignition subsystems.

I = Idle related adjustments only.

were to inspect for all listed malfunctions, thus an additional cost for diagnosis is incurred even though no failures were present. This statement is also true to a more limited extent with the emission inspection instruction fleet since a California Certificate of Compliance which requires the use of an electronic ignition analyzer was also requested for this fleet.

6.0 SUMMARY AND CONCLUSIONS

The data and discussion presented in Section 5.0 suggests the following conclusions:

- The maintenance effectiveness of all three service organization types is marginal at best with regard to most of the engine parameters investigated.
- The probability of detecting idle CO, idle speed, basic timing and choke blade kick angle maladjustments is significantly higher than the effectiveness in setting those parameters to within specification tolerances.
- Service organization effectiveness in detecting and repairing failed components which can be corrected by simple parts replacement is variable. Effectiveness is higher for those components which are familiar to mechanics (PCV valve, spark plug, air cleaner elements and ignition wires). Effectiveness is low for new components such as NO_x controls.
- Unnecessary repairs can be expected to occur. The absolute magnitude of the costs incurred is highly speculative on the basis of the data available from this program, but can run from 10 to 30 percent of the repair bill.

Possible causes for the variable maintenance effectiveness have been speculated upon in Section 5.0. This work has shown that the full benefit of a mandatory emission inspection and maintenance program cannot be realized with current service organization practices and procedures. The data strongly suggest that a large number of repair agencies do not have systematic, accurate procedures for diagnosing engine tune-up related malfunctions and maladjustments. Additional investigations should be conducted to determine the causes of the overall low maintenance effectiveness prior to implementating mandatory vehicle inspection and maintenance programs.

Although these conclusions are based upon data acquired in Southern California, it is unlikely that trends differ markedly on a national basis. If anything, the quantitative results may be optimistic since: 1) only California certified class A garages were used which are authorized to issue Certificates of Compliance for exhaust controls and 2) infrequent inquiries concerning the test vehicles showed concern that the Highway Patrol might be auditing performance which have motivated better performance.

APPENDIX A

Supplementary Data

1.0 INTRODUCTION

The data shown in Section 5.0 were combined and condensed to illustrate the major effects observed in analyzing the experimental data. This Appendix contains expanded tables and charts showing the data in more detail.

2.0 EXPERIMENT DATA

Tables A-1 through A-5 show the experimental data in terms of numbers of malfunctions submitted and corrected for each parameter investigated. Tables A-6 through A-16 show the individual vehicle parameter malfunction and repair data for each parameter tested. Tables A-17 through A-26 show the compilation of all raw data by vehicle, Service Organization and instructions.

Table A-27 summarizes the key mode emissions measured for the emission inspection fleet, vehicles 1 to 5. Since these emissions were periodically monitored throughout the experiment, ranges of their values are given. Where malfunctions were changed early in the experiment, only those emission signatures carried through to program completion are given.

TABLE A-1

ABILITY OF SERVICE ORGANIZATIONS TO DETECT MALFUNCTIONS

		INDEPENDENTS		DEALERSHIPS		SERVICE STATIONS	
		EMISSION VEHICLES	PARAMETER VEHICLES	EMISSION VEHICLES	PARAMETER VEHICLES	EMISSION VEHICLES	PARAMETER VEHICLES
TOTAL MALFUNCTIONS	S.B.	96	134	94	135	100	135
	RIV.	37	108	40	104	40	108
MALFUNCTIONS FOUND	S.B.	52	69	57	79	61	60
	RIV.	20	58	33	58	24	44
MALFUNCTIONS NOT FOUND	S.B.	44	65	37	56	39	75
	RIV.	17	50	7	46	16	64
% MALFUNCTIONS FOUND	S.B.	54%	52%	61%	59%	61%	44%
	RIV.	54%	54%	83%	56%	60%	41%

TABLE A-2

REPAIR ACCURACY (% OF VEHICLES WITHIN LIMITS)
IDLE CO

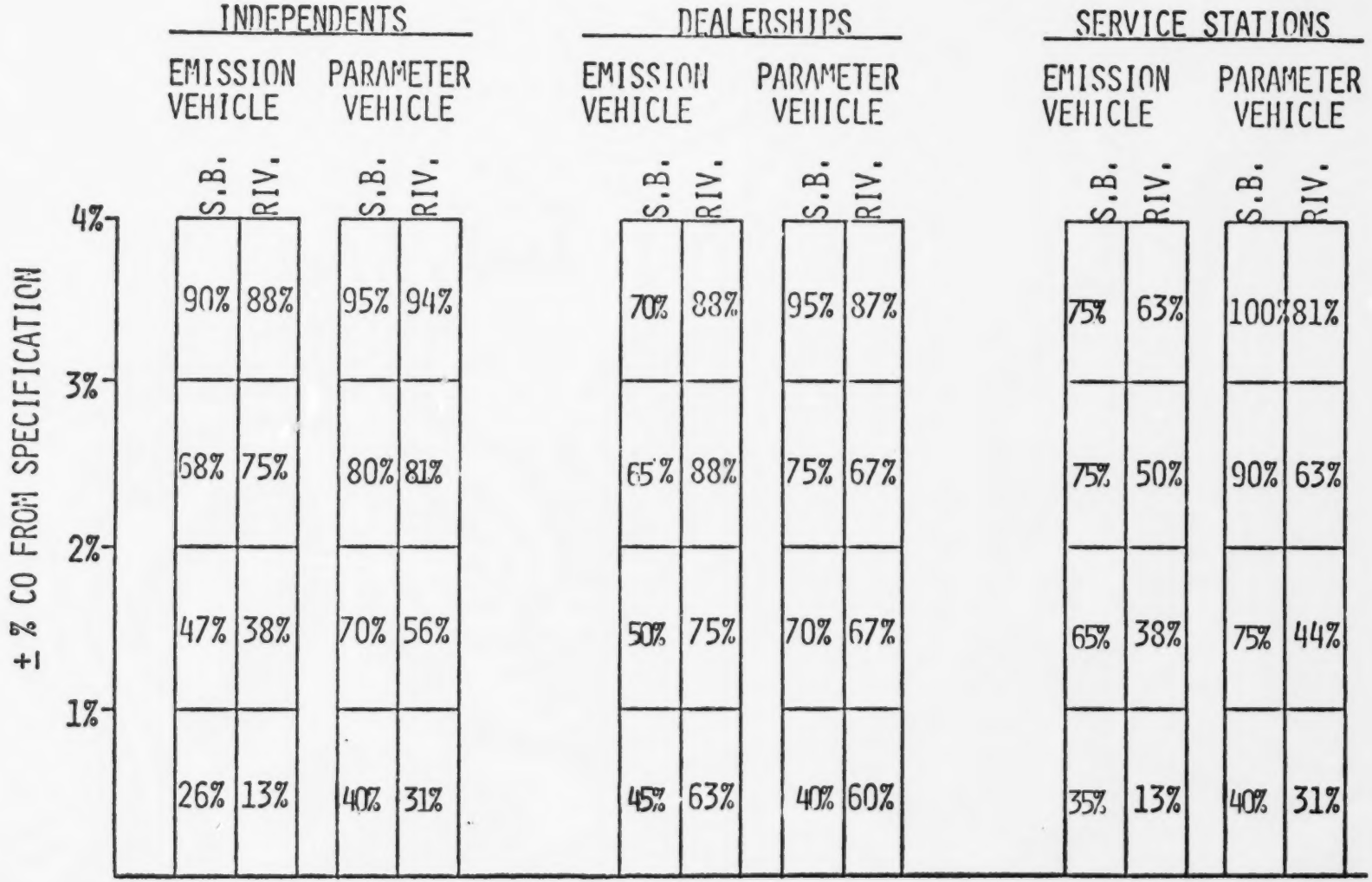


TABLE A-3

REPAIR ACCURACY (% OF VEHICLES WITHIN LIMITS)
IDLE R.P.M.

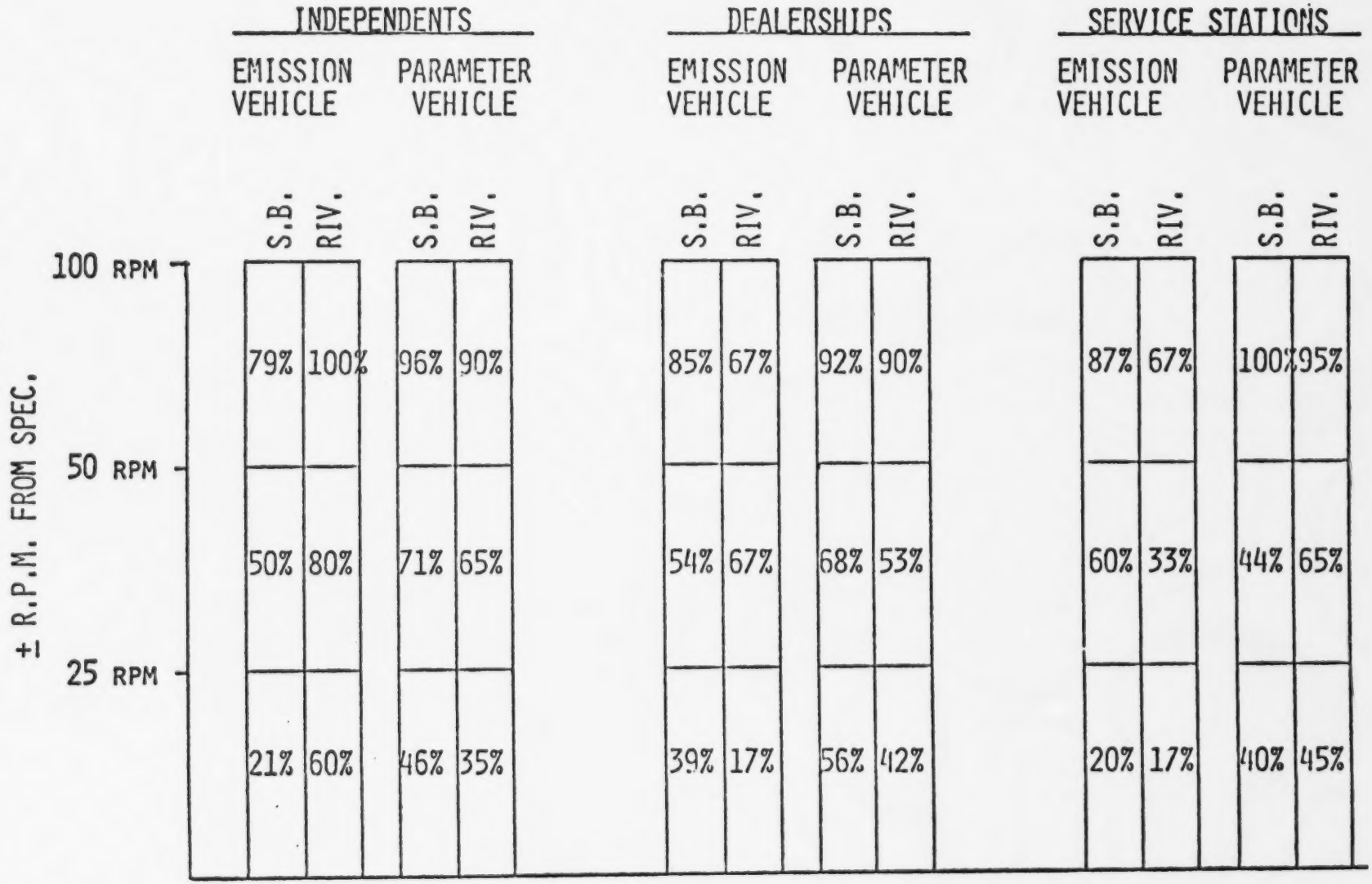


TABLE A-4

REPAIR ACCURACY (% OF VEHICLES WITHIN LIMITS)
BASIC TIMING

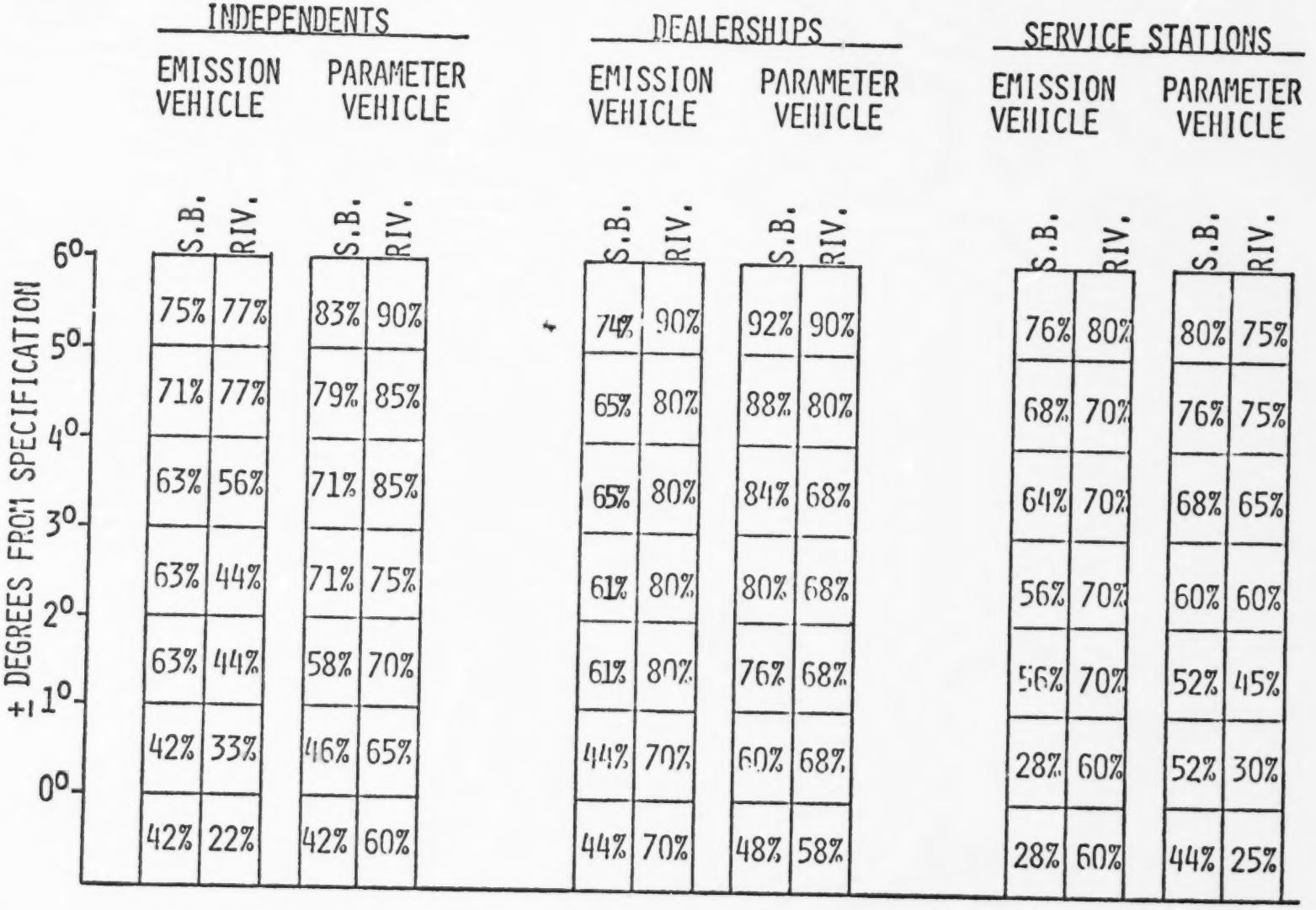


TABLE A-5

ABILITY TO DETECT AND FIX MALFUNCTIONS OTHER THAN IDLE CO, RPM, AND TIMING

		INDEPENDENTS				DEALERSHIPS				SERVICE STATIONS				
		EMISSION		PARAMETER		EMISSION		PARAMETER		EMISSION		PARAMETER		TOTAL
MALFUNCTION	CITY	NO. SENT	NO. FOUND	NO. SENT	NO. FOUND	NO. SENT	NO. FOUND	NO. SENT	NO. FOUND	NO. SENT	NO. FOUND	NO. SENT	NO. FOUND	PERCENT FOUND
NO_x CONTROL	S.B.	5	0	14	4	5	2	15	6	5	1	15	2	21
	RIV.	2	0	12	1	2	2	11	3	2	0	12	0	
MISFIRE (PLUGWIRE)	S.B.	9	8	5	1	10	8	5	4	10	10	5	2	79
	RIV.	4	4	4	3	4	4	4	4	4	4	4	2	
MISFIRE (SPARK PLUG)	S.B.	5	5	10	8	3	3	10	10	5	3	10	8	90
	RIV.	1	1	8	8	2	2	8	8	2	2	8	7	
AIR CLEANER	S.B.	10	6	10	8	10	7	10	7	10	8	10	8	73
	RIV.	4	3	8	8	4	4	8	4	4	4	8	4	
P.C.V. VALVE	S.B.	5	4	9	6	5	4	5	2	5	5	5	5	77
	RIV.	2	2	4	4	2	2	4	3	2	2	4	1	
HEAT RISER	S.B.	5	2	9	3	5	3	10	4	5	4	10	2	36
	RIV.	2	1	8	1	2	2	8	2	2	2	8	1	
BLADE SETTING	S.B.	---	---	9	0	---	---	10	2	---	---	10	1	15
	RIV.	---	---	8	1	---	---	8	2	---	---	8	2	
TOTALS	S.B.	39	25	66	30	38	27	65	35	40	31	65	28	
	RIV.	15	11	52	26	16	16	51	26	16	14	52	17	

TABLE A-6

PARAMETER MALFUNCTION DETECTION AND REPAIR

IDLE CO

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1*	CHEVROLET	1964	21	21	100.0	0	0
2*	FORD	1970	20	11	55.0	6	30.0
3*	CHEVROLET	1971	21	18	85.7	11	52.4
4*	PLYMOUTH	1970	21	14	66.7	11	52.4
5	VOLKSWAGEN	1971	18	(-)	(-)	11	61.1
6	CHRYSLER	1971	26	(-)	(-)	15	57.7
7*	CHEVROLET	1965	27	25	92.6	8	29.6
8*	FORD	1971	27	21	77.8	9	33.3
9*	CHEVROLET	1970	27	26	96.3	15	55.5
10*	AM. MTRS.	1971	26	23	88.5	11	42.3

*Parameters were malfunctioned when submitted to service organization.

(-) Parameter was not malfunctioned when submitted to service organization. Service organization maintenance resulted in some vehicles being out of specification when returned to Scott.

TABLE A-7

PARAMETER MALFUNCTION DETECTION AND REPAIR

IDLE RPM

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1	CHEVROLET	1964	21	(-)	(-)	14	66.6
2*	FORD	1970	20	16	80.0	9	45.0
3*	CHEVROLET	1971	21	14	66.7	14	66.7
4	PLYMOUTH	1970	21	(-)	(-)	10	47.7
5	VOLKSWAGEN	1971	18	-	-	10	55.6
6	CHRYSLER	1971	26	-	-	9	30.8
7	CHEVROLET	1965	27	-	-	16	59.3
8	FORD	1971	27	-	-	18	66.7
9*	CHEVROLET	1970	27	25	92.6	20	74.1
10*	AM. MTRS.	1971	26	25	96.2	18	69.2

*Parameters were malfunctioned when submitted to service organization.

(-) Parameter was not malfunctioned when submitted to service organization. Service organization maintenance resulted in some vehicles being out of specification when returned to Scott.

TABLE A-8

PARAMETER MALFUNCTION DETECTION AND REPAIR

BASIC TIMING

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1*	CHEVROLET	1964	21	17	81.0	11	52.4
2*	FORD	1970	20	-	-	14	70.0
3*	CHEVROLET	1971	21	-	-	21	100.0
4*	PLYMOUTH	1970	21	17	81.0	10	47.6
5*	VOLKSWAGEN	1971	18	10	55.5	6	33.3
6*	CHRYSLER	1971	26	23	88.5	14	53.8
7*	CHEVROLET	1965	27	24	88.9	21	77.8
8*	FORD	1971	27	19	70.4	12	44.4
9*	CHEVROLET	1970	27	24	88.9	18	66.7
10*	AM. MTRS.	1971	26	23	88.5	17	65.4

*Parameters were malfunctioned when submitted to service organization.

TABLE A-9

PARAMETER MALFUNCTION DETECTION AND REPAIR

CHOKE BLADE

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1	CHEVROLET	1964	(-)	-	-	-	-
2	FORD	1970	(-)	-	-	-	-
3	CHEVROLET	1970	(-)	-	-	-	-
4	PLYMOUTH	1970	(-)	-	-	-	-
5	VOLKSWAGEN	1971	(-)	-	-	-	-
6	CHRYSLER	1971	26	7	26.9	3	11.5
7	CHEVROLET	1965	(-)	-	-	-	-
8	FORD	1971	(-)	-	-	-	-
9	CHEVROLET	1970	27	10	37.0	5	18.5
10	AM. MTRS.	1971	-	-	-	-	-

(-) Parameter was not malfunctioned when submitted to service organization.

TABLE A-10

PARAMETER MALFUNCTION DETECTION AND REPAIR

AIR CLEANER

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1	CHEVROLET	1964	21	18	85.7	18	85.7
2	FORD	1970	(-)	(-)	(-)	(-)	(-)
3	CHEVROLET	1971	(-)	(-)	-	(-)	(-)
4	PLYMOUTH	1970	21	14	66.7	14	66.7
5	VOLKSWAGEN	1971	(-)	(-)	(-)	(-)	(-)
6	CHRYSLER	1971	(-)	(-)	(-)	(-)	(-)
7	CHEVROLET	1965	27	20	74.1	20	74.1
8	FORD	1971	27	19	70.4	19	70.4
9	CHEVROLET	1970	(-)	(-)	(-)	(-)	(-)
10	AM. MTRS.	1971	(-)	(-)	(-)	(-)	(-)

(-) Air cleaner was not malfunctioned when submitted to Service Organization.

TABLE A-11

PARAMETER MALFUNCTION DETECTION AND REPAIR

MISFIRE (SPARK PLUG)

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1	CHEVROLET	1964	(-)	(-)	-	-	-
2	FORD	1970	(-)	(-)	-	-	-
3	CHEVROLET	1971	(-)	(-)	-	-	-
4	PLYMOUTH	1970	(-)	(-)	-	-	-
5	VOLKSWAGEN	1971	18	16	88.9	16	88.9
6	CHRYSLER	1971	(-)	(-)	-	-	-
*7	CHEVROLET	1965	4	2	50.0	2	50.0
8	FORD	1971	27	26	96.3	26	96.3
9	CHEVROLET	1970	23	21	91.3	21	91.3
10	AM. MTRS.	1971	(-)	(-)	(-)	(-)	(-)

*San Bernardino Independent Garage Only!

(-) Spark plug not malfunctioned when submitted to Service Organizagion.

TABLE A-12

PARAMETER MALFUNCTION DETECTION AND REPAIR

MISFIRE (PLUG WIRE)

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1	CHEVROLET	1964	(-)	(-)	(-)	-	-
2	FORD	1970	20	17	85.0	17	85.0
3	CHEVROLET	1971	21	21	100.0	21	100.0
4	PLYMOUTH	1970	(-)	(-)	(-)	-	-
5	VOLKSWAGEN	1971	(-)	(-)	-	-	-
6	CHRYSLER	1971	(-)	(-)	-	-	-
*7	CHEVROLET	1965	4	1	25.0	1	25.0
8	FORD	1971	(-)	(-)	-	-	-
9	CHEVROLET	1970	23	15	65.2	15	65.2
10	AM. MTRS.	1971	(-)	(-)	-	-	-

*San Bernardino Independent Garage Only!

(-) Plug wire not malfunctioned when submitted to Service Organization.

TABLE A-13

PARAMETER MALFUNCTION DETECTION AND REPAIR

PCV VALVE

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1	CHEVROLET	1964	21	19	90.5	19	90.5
2	FORD	1970	(-)	(-)	(-)	-	-
3	CHEVROLET	1971	(-)	(-)	(-)	-	-
4	PLYMOUTH	1970	(-)	(-)	(-)	-	-
5	VOLKSWAGEN	1971	(-)	(-)	(-)	-	-
6	CHRYSLER	1971	(-)	(-)	(-)	-	-
7	CHEVROLET	1965	23	16	69.6	16	69.6
8	FORD	1971	(-)	(-)	(-)	-	-
*9	CHEVROLET	1970	4	2	50.0	2	50.0
*10	AM. MTRS.	1971	4	3	75.0	3	75.0

*San Bernardino Independent Garage Only!

(-) PCV valve not malfunctioned when supmitted to Service Organization.

TABLE A-14

PARAMETER MALFUNCTION DETECTION AND REPAIR

HEAT RISER

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1	CHEVROLET	1964	21	14	66.7	14	66.7
2	FORD	1970	(-)	-	-	-	-
3	CHEVROLET	1971	(-)	-	-	-	-
4	PLYMOUTH	1970	(-)	-	-	-	-
5	VOLKSWAGEN	1971	(-)	-	-	-	-
6	CHRYSLER	1971	26	4	15.4	4	15.4
7	CHEVROLET	1965	(-)	-	-		
8	FORD	1971	(-)	-	-	-	-
9	CHEVROLET	1970	27	9	33.3	9	33.3
10	AM. MTRS.	1971	-	-	-	-	-

(-) Heat riser not malfunctioned when submitted to service organizations.

TABLE A-15

PARAMETER MALFUNCTION DETECTION AND REPAIR

NOX CONTROL DEVICE

CAR NO.	MAKE	YEAR	TOTAL NO.	DETECTION		ADJUSTMENT TO SPEC.	
				NO.	%	NO.	%
1	CHEVROLET	1964	(-)	-	-	-	-
2	FORD	1970	(-)	-	-	-	-
3	CHEVROLET	1971	21	5	23.8	5	23.8
4	PLYMOUTH	1970	(-)	-	-	-	-
5	VOLKSWAGEN	1971	(-)	-	-	-	-
6	CHRYSLER	1971	26	2	7.7	2	7.7
7	CHEVROLET	1965	(-)	-	-	-	-
8	FORD	1971	(-)	-	-	-	-
9	CHEVROLET	1970	27	11	40.7	11	40.7
10	AM. MTRS.	1971	26	3	11.5	3	11.5

(-) NO_x control device not malfunctioned when submitted to Service Organizations.

TABLE A-16

IDLE CO (% v) BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	SPEC	STATE	SAN BERNARDINO																RIVERSIDE											
		LOCATION		INDEPENDENT GARAGE					DEALER					SERVICE STATION					INDEPENDENT GARAGE				DEALER				SERVICE STATION					
		REPAIR STATION																													
		STATION NO		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	
				EMISSION INSPECTION FLEET																											
1.	CHEVROLET 1964	6.69 ± 1%	PRE-TUNE	9.69	9.69	9.69	9.69	9.69	9.69	9.69	9.69	9.68	9.69	9.69	9.69	9.69	9.69	9.69	9.69	9.69	—	—	9.69	9.69	—	—	9.69	9.69	—	—	
			POST-TUNE	3.00	5.39	5.00	4.60	4.20	0.10	1.50	4.58	3.81	0.20	5.54	0.62	5.45	1.98	3.96	3.58	5.00	—	—	5.50	4.50	—	—	1.30	5.00	—	—	
2.	FORD 1970	0.75 ± 1%	PRE-TUNE	4.25	4.25	4.25	—	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	4.25	—	—	4.25	4.25	—	—	4.25	4.25	—	—	
			POST-TUNE	3.20	2.50	0.70	—	5.00	0.50	5.00	2.40	5.00	0.20	1.50	5.00	3.00	3.50	5.00	2.80	4.90	—	—	0.20	5.00	—	—	5.00	1.10	—	—	
3.	CHEVROLET 1971	0.50 ± 1%	PRE-TUNE	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	—	—	4.00	4.00	—	—	4.00	4.00	—	—	
			POST-TUNE	0.10	0.70	0.30	4.50	1.70	0.20	5.00	0.50	0.10	1.50	2.00	2.10	2.90	1.50	0.10	3.20	2.80	—	—	0.10	0.10	—	—	5.00	1.60	—	—	
4.	PLYMOUTH 1970	1.00 ± 1%	PRE-TUNE	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	—	—	4.00	4.00	—	—	4.00	4.00	—	—	
			POST-TUNE	5.10	4.00	0.30	5.00	4.10	3.50	2.00	0.40	5.00	0.30	2.00	1.50	1.60	0.25	2.70	1.30	2.30	—	—	0.20	1.90	—	—	4.00	4.90	—	—	
5.	VOLKSWAGEN 1971	1.50-3.00	PRE-TUNE	2.00	1.50	1.50	2.00	1.50	2.50	1.50	—	—	2.50	2.00	1.50	1.50	1.50	1.50	1.90	—	—	—	2.80	2.20	—	—	2.00	1.50	—	—	
			POST-TUNE	4.00	2.00	0.70	3.00	0.50	2.10	1.50	—	—	2.00	1.90	0.80	2.10	0.10	2.50	1.80	—	—	—	1.30	1.20	—	—	4.00	4.90	—	—	
				PARAMETER INSPECTION FLEET																											
6.	CHRYSLER 1971	1.00 ± 1%	PRE-TUNE	0.17	1.00	1.00	—	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
			POST-TUNE	6.00	1.00	0.12	—	0.30	4.50	1.50	1.00	0.10	3.80	2.20	1.00	2.00	0.50	4.50	5.00	2.10	2.30	0.15	0.25	0.10	0.10	4.50	0.20	1.50	2.30	3.90	
7.	CHEVROLET 1965	4.48 ± 1%	PRE-TUNE	9.51	10.0	10.0	7.90	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	8.98	
			POST-TUNE	4.00	0.10	3.63	8.60	3.50	8.98	8.15	5.00	6.01	0.15	6.90	5.00	4.50	5.50	2.80	5.00	1.39	7.00	4.20	0.50	6.00	7.79	8.00	5.00	5.00	6.00	7.50	
8.	FORD 1971	0.40 ± 1%	PRE-TUNE	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.40	
			POST-TUNE	1.79	2.16	2.59	0.66	3.70	3.50	3.10	0.10	1.50	2.20	3.50	2.30	1.00	3.90	1.00	1.30	2.20	5.00	1.00	1.30	0.90	5.00	4.50	1.30	5.00	5.00	4.60	
9.	CHEVROLET 1970	1.00 ± 1%	PRE-TUNE	4.89	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.00	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	
			POST-TUNE	3.90	1.70	0.50	0.10	0.30	1.00	2.50	0.30	1.25	0.12	1.90	3.00	3.50	3.00	0.50	3.20	2.50	3.20	0.60	1.60	0.10	1.80	2.00	3.40	4.00	5.00	3.40	
10.	AMERICAN MOTORS 1971	1.00-1.50	PRE-TUNE	5.00	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	—	4.75	4.75	4.75	4.75	4.75	4.75	4.75	
			POST-TUNE	2.20	2.60	0.12	2.50	0.30	4.75	0.90	0.20	0.70	0.20	5.00	0.50	0.20	1.50	3.50	0.20	4.00	4.50	2.10	1.50	0.40	1.80	—	0.30	0.30	3.10	5.00	

TABLE A-17

IDLE RPM (rpm) BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	LOCATION		SAN BERNARDINO															RIVERSIDE											
		REPAIR STATION		INDEPENDENT GARAGE					DEALER					SERVICE STATION					INDEPENDENT GARAGE				DEALER				SERVICE STATION			
		STATION NO		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
		SPEC	STATE											EMISSION INSPECTION FLEET																
1.	CHEVROLET 1964	500	PRE-TUNE	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	—	—	500	500	—	—	500	500	—	—
		±50	POST-TUNE	575	475	475	475	425	490	500	410	475	475	475	500	625	600	500	500	475	—	—	450	575	—	—	375	475	—	—
2.	FORD 1970	600	PRE-TUNE	530	530	530	—	530	530	530	530	530	530	530	530	530	530	530	530	530	—	—	530	530	—	—	530	530	—	—
		±50	POST-TUNE	700	650	575	—	575	820	575	525	450	600	500	650	525	475	675	650	675	—	—	575	375	—	—	450	600	—	—
3.	CHEVROLET 1971	550	PRE-TUNE	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	480	—	—	480	480	—	—	480	480	—	—
		±50	POST-TUNE	475	500	525	450	450	500	525	525	465	500	500	550	500	500	475	525	525	—	—	400	500	—	—	475	500	—	—
4.	PLYMOUTH 1970	750	PRE-TUNE	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	750	—	—	750	750	—	—	750	750	—	—
		±50	POST-TUNE	750	725	775	575	675	750	675	625	650	800	650	850	700	800	650	600	700	—	—	700	800	—	—	625	675	—	—
5.	VOLKSWAGEN 1971	850	PRE-TUNE	900	900	900	900	900	900	900	—	—	900	900	900	900	900	900	900	—	—	—	900	900	—	—	900	900	—	—
		±50	POST-TUNE	800	1050	1000	900	700	935	950	—	—	850	850	1050	900	900	850	875	—	—	—	800	900	—	—	950	1200	—	—
														PARAMETER INSPECTION FLEET																
6.	CHRYSLER 1971	750	PRE-TUNE	800	800	800	—	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800
		±50	POST-TUNE	800	700	775	—	750	675	750	750	900	650	800	825	650	675	675	675	675	465	575	675	600	850	650	625	750	700	650
7.	CHEVROLET 1965	450	PRE-TUNE	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
		±50	POST-TUNE	425	550	400	475	525	375	510	475	465	450	475	550	525	450	525	510	510	400	475	550	450	425	400	400	450	415	550
8.	FORD 1971	625	PRE-TUNE	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575	575
		±50	POST-TUNE	625	600	575	625	550	600	575	575	575	525	525	625	600	535	550	625	535	575	575	650	525	500	600	625	550	625	600
9.	CHEVROLET 1970	600	PRE-TUNE	450	450	450	450	450	450	450	500	450	450	450	450	500	450	450	450	450	450	450	450	500	500	500	450	480	450	500
		±50	POST-TUNE	725	600	500	625	625	575	600	575	625	475	575	600	525	575	500	600	625	635	550	500	600	625	550	575	570	515	575
10.	AMERICAN MOTORS 1971	600	PRE-TUNE	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	450	—	450	450	450	450
		±50	POST-TUNE	625	560	675	540	600	575	575	600	525	600	575	600	600	525	500	600	650	600	600	575	525	625	—	675	600	450	600

TABLE A-18

BASIC TIMING (degrees) BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	SPEC	STATE	SAN BERNARDINO															RIVERSIDE											
				INDEPENDENT GARAGE					DEALER					SERVICE STATION					INDEPENDENT GARAGE				DEALER				SERVICE STATION			
				1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
				EMISSION INSPECTION FLEET																										
1.	CHEVROLET 1964	4° ± 2°	PRE-TUNE	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	—	—	14	14	—	—	14	14	—	—
			POST-TUNE	14	6	4	4	4	6	10	4	4	10	8	-2	14	14	14	8	14	—	—	4	4	—	—	4	4	—	—
2.	FORD 1970	6° ± 2°	PRE-TUNE	8	8	8	—	8	8	8	8	8	8	8	8	8	8	8	8	8	—	—	8	8	—	—	8	8	—	—
			POST-TUNE	8	0	4	—	14	8	10	6	8	6	4	8	8	0	4	8	14	—	—	8	6	—	—	6	12	—	—
3.	CHEVROLET 1971	8° ± 2°	PRE-TUNE	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	—	—	10	10	—	—	10	10	—	—
			POST-TUNE	8	10	8	8	8	8	8	8	10	8	8	6	10	8	10	9	8	—	—	8	8	—	—	8	6	—	—
4.	PLYMOUTH 1970	0 ± 2°	PRE-TUNE	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	—	—	10	10	—	—	10	10	—	—
			POST-TUNE	8	10	-2	0	0	10	-12	0	10	0	0	4	8	0	0	5	5	—	—	6	0	—	—	0	10	—	—
5.	VOLKSWAGEN 1971	-5° ± 2°	PRE-TUNE	-15	-15	-15	-15	-15	-15	-15	—	—	-15	-15	-15	-15	-15	-15	-15	—	—	—	-15	-15	—	—	-15	-15	—	—
			POST-TUNE	-5	-15	0	0	-15	-15	-15	—	—	-15	-15	0	-5	+15	-5	-5	—	—	—	-5	-15	—	—	-15	-5	—	—
				PARAMETER INSPECTION FLEET																										
6.	CHRYSLER 1971	5° ± 2°	PRE-TUNE	15	15	15	—	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
			POST-TUNE	8	5	6	—	10	7	5	3	7	5	8	5	0	15	5	-5	3	5	5	0	5	5	5	7	15	15	0
7.	CHEVROLET 1965	4° ± 2°	PRE-TUNE	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
			POST-TUNE	4	4	4	4	6	11	5	4	5	9	9	4	4	8	4	4	4	4	4	4	4	4	4	4	4	11	11
8.	FORD 1971	6° ± 2°	PRE-TUNE	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
			POST-TUNE	8	16	13	6	16	6	6	16	6	12	16	12	6	16	16	6	16	6	12	16	6	7	12	6	3	10	4
9.	CHEVROLET 1976	4° ± 2°	PRE-TUNE	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
			POST-TUNE	6	10	4	4	14	5	6	8	6	4	8	4	5	14	7	8	4	3	4	4	4	10	5	4	3	14	6
10.	AMERICAN MOTORS 1971	5° ± 2°	PRE-TUNE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—	0	0	0	0
			POST-TUNE	5	8	5	2	0	5	5	5	2	5	5	5	5	5	6	5	5	7	9	0	5	14	—	2	5	0	2

TABLE A-19

CHOKE KICK (BLADE) SETTING (in) BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	LOCATION		SAN BERNARDINO																RIVERSIDE									
		REPAIR STATION		INDEPENDENT GARAGE					DEALER					SERVICE STATION					INDEPENDENT GARAGE				DEALER				SERVICE STATION			
		STATION NO		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
		SPEC	STATE											EMISSION INSPECTION FLEET																
1.	CHEVROLET 1964	.080-.105	PRE-TUNE	.100	.100	.090	.090	.090	—	.090	.090	.090	.090	.100	.100	.100	.100	.090	.090	.100	—	—	.100	.100	—	—	.100	.00	—	—
		±.100	POST-TUNE	.100	.100	.090	.090	.090	.060	.100	.090	.100	.120	.100	.100	.100	.100	.090	.100	.100	—	—	.100	.100	—	—	.100	.100	—	—
2.	FORD 1970	.150	PRE-TUNE	.150	.150	.150	—	.150	.150	.150	.150	.150	.150	.150	.150	.150	.150	.150	.150	.150	—	—	.150	.150	—	—	.150	.150	—	—
		±.100	POST-TUNE	.150	.150	.150	—	.150	.150	.150	.150	.150	.150	.150	.150	.150	.150	.150	.150	.150	—	—	.150	.150	—	—	.250	.150	—	—
3.	CHEVROLET 1971	.260	PRE-TUNE	.260	.260	.260	.260	.260	.260	.260	.260	.260	.260	.260	.260	.260	.260	.260	.260	.260	—	—	.260	.260	—	—	.260	.260	—	—
		±.100	POST-TUNE	.260	.260	.260	.260	.260	.160	—	.215	.260	.260	.245	.260	.260	.260	.260	.260	.260	—	—	.260	.260	—	—	.260	.260	—	—
4.	PLYMOUTH 1970	.169	PRE-TUNE	.169	.169	.169	.169	.169	.169	.169	.169	.169	.169	.170	.169	.169	.169	.169	.169	.169	—	—	.169	.169	—	—	.169	.169	—	—
		±.100	POST-TUNE	.150	.169	.169	.169	.169	.169	.169	.170	.169	.169	.150	.169	.169	.169	.169	.169	.169	—	—	.169	.169	—	—	.150	.169	—	—
5.	VOLKSWAGEN 1971		PRE-TUNE																											
			POST-TUNE																											
														PARAMETER INSPECTION FLEET																
6.	CHRYSLER 1971	.086	PRE-TUNE	0	0	0	—	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		±.100	POST-TUNE	0	0	0	—	0	0	0	.060	0	0	0	.190	0	0	0	.200	.200	0	0	0	.060	0	.200	.110	0	0	0
7.	CHEVROLET 1965	.090	PRE-TUNE	—	—	—	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090	.090
		±.100	POST-TUNE	—	—	—	.120	.090	.090	.090	.090	.090	.120	.090	.090	.090	.090	.090	.120	.190	.130	.090	.090	.090	.090	.090	.090	.090	.090	.090
8.	FORD 1971	.190	PRE-TUNE	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190
		±.100	POST-TUNE	.215	.190	.120	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190	.250	.190	.190	.190	.190	.190	.190	.190	.190	.190	.190
9.	CHEVROLET 1970	.245	PRE-TUNE	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.120	.125	0	.120	.120
		±.100	POST-TUNE	.120	.120	.120	.450	.095	.110	.120	.170	.120	.050	.180	.120	.120	.120	.120	.245	.120	.120	.120	0	.215	.120	.140	.175	0	.120	.120
10.	AMERICAN MOTORS 1971		PRE-TUNE																											
			POST-TUNE																											

TABLE A-20

AIR CLEANER (degrees or condition) BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	SPEC	STATE	SAN BERNARDINO																RIVERSIDE									
		LOCATION		INDEPENDENT GARAGE					DEALER					SERVICE STATION					INDEPENDENT GARAGE				DEALER				SERVICE STATION			
		REPAIR STATION																											
		STATION NO		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
				EMISSION INSPECTION FLEET																									
1.	CHEVROLET 1964		PRE-TUNE	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	—	—	180	180	—	—	180	180	—	—
			POST-TUNE	180	CL	CL	CL	CL	CL	CL	CL	CL	CL	180	CL	180	CL	CL	CL	CL	—	—	CL	CL	—	—	CL	CL	—	—
2.	FORD 1970		PRE-TUNE																										
			POST-TUNE																										
3.	CHEVROLET 1971		PRE-TUNE																										
			POST-TUNE																										
4.	PLYMOUTH 1970		PRE-TUNE	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	—	—	180	180	—	—	170	180	—	—
			POST-TUNE	180	180	CL	180	CL	180	CL	CL	180	180	CL	CL	CL	CL	CL	CL	180	—	—	CL	CL	—	—	CL	CL	—	—
5.	VOLKSWAGEN 1971		PRE-TUNE																										
			POST-TUNE																										
				PARAMETER INSPECTION FLEET																									
6.	CHRYSLER 1971		PRE-TUNE																										
			POST-TUNE																										
7.	CHEVROLET 1965		PRE-TUNE	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
			POST-TUNE	180	CL	CL	CL	CL	180	CL	CL	CL	180	180	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	180	180	CL	180	CL
8.	FORD 1971		PRE-TUNE	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180
			POST-TUNE	CL	180	CL	CL	CL	CL	CL	CL	CL	180	180	CL	CL	CL	CL	CL	CL	CL	CL	180	CL	180	180	CL	180	180	CL
9.	CHEVROLET 1970		PRE-TUNE																										
			POST-TUNE																										
10.	AMERICAN MOTORS 1971		PRE-TUNE																										
			POST-TUNE																										

TABLE A-21

SPARK PLUG (%misfire) BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	SPEC	STATE	SAN BERNARDINO																RIVERSIDE											
				INDEPENDENT GARAGE					DEALER					SERVICE STATION					INDEPENDENT GARAGE				DEALER				SERVICE STATION			
				1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
				EMISSION INSPECTION FLEET																											
1.	CHEVROLET 1964		PRE-TUNE																												
			POST-TUNE																												
2.	FORD 1970		PRE-TUNE																												
			POST-TUNE																												
3.	CHEVROLET 1971		PRE-TUNE																												
			POST-TUNE																												
4.	PLYMOUTH 1970		PRE-TUNE																												
			POST-TUNE																												
5.	VOLKSWAGEN 1971		PRE-TUNE	6	6	6	6	6	6	6	—	—	6	6	6	6	6	6	—	6	—	—	6	6	—	—	6	6	—	—
			POST-TUNE	0	0	0	0	0	0	0	—	—	0	0	6	0	6	0	—	0	—	—	0	0	—	—	0	0	—	—
				PARAMETER INSPECTION FLEET																											
6.	CHRYSLER 1971		PRE-TUNE																												
			POST-TUNE																												
7.	CHEVROLET 1965		PRE-TUNE	6	6	6	6	—																							
			POST-TUNE	6	6	0	0	—																							
8.	FORD 1971		PRE-TUNE	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
			POST-TUNE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0
9.	CHEVROLET 1970		PRE-TUNE	—	—	—	—	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
			POST-TUNE	—	—	—	—	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	6
10.	AMERICAN MOTORS 1971		PRE-TUNE																												
			POST-TUNE																												

TABLE A-22

SPARK PLUG WIRE (%misfire) BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	SPEC	STATE	SAN BERNARDINO															RIVERSIDE											
		LOCATION		INDEPENDENT GARAGE					DEALER					SERVICE STATION					INDEPENDENT GARAGE				DEALER				SERVICE STATION			
		REPAIR STATION																												
		STATION NO		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
														EMISSION INSPECTION FLEET																
1.	CHEVROLET 1964		PRE-TUNE																											
			POST-TUNE																											
2.	FORD 1970		PRE-TUNE	12	12	12	—	12	12	12	12	12	12	12	12	12	12	12	12	12	—	—	12	12	—	—	12	12	—	—
			POST-TUNE	0	0	0	—	12	12	0	0	12	0	0	0	0	0	0	0	0	—	—	0	0	—	—	0	0	—	—
3.	CHEVROLET 1971		PRE-TUNE	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	—	—	12	12	—	—	12	12	—	—
			POST-TUNE	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	—	—	0	0	—	—	0	0	—	—
4.	PLYMOUTH 1970		PRE-TUNE																											
			POST-TUNE																											
5.	VOLKSWAGEN 1971		PRE-TUNE																											
			POST-TUNE																											
														PARAMETER INSPECTION FLEET																
6.	CHRYSLER 1971		PRE-TUNE																											
			POST-TUNE																											
7.	CHEVROLET 1965		PRE-TUNE	12	12	12	12	—																						
			POST-TUNE	12	12	12	0	—																						
8.	FORD 1971		PRE-TUNE																											
			POST-TUNE																											
9.	CHEVROLET 1970		PRE-TUNE	—	—	—	—	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
			POST-TUNE	—	—	—	—	12	0	12	0	0	0	0	12	12	0	12	0	12	0	0	0	0	0	0	0	12	12	0
10.	AMERICAN MOTORS 1971		PRE-TUNE																											
			POST-TUNE																											

TABLE A-23

PCV VALVE CONDITION BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	LOCATION		SAN BERNARDINO																RIVERSIDE											
		REPAIR STATION		INDEPENDENT GARAGE					DEALER					SERVICE STATION						INDEPENDENT GARAGE				DEALER				SERVICE STATION			
		STATION NO		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5		1	2	3	4	1	2	3	4	1	2	3	4
														EMISSION INSPECTION FLEET																	
		SPEC	STATE																												
1.	CHEVROLET 1964		PRE-TUNE	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG		NG	NG	—	—	NG	NG	—	—	NG	NG	—	—
			POST-TUNE	OK	OK	OK	OK	NG	OK	OK	NG	OK	OK	OK	OK	OK	OK	OK		OK	OK	—	—	OK	OK	—	—	OK	OK	—	—
2.	FORD 1970		PRE-TUNE																												
			POST-TUNE																												
3.	CHEVROLET 1971		PRE-TUNE																												
			POST-TUNE																												
4.	PLYMOUTH 1970		PRE-TUNE																												
			POST-TUNE																												
5.	VOLKSWAGEN 1971		PRE-TUNE																												
			POST-TUNE																												
														PARAMETER INSPECTION FLEET																	
6.	CHRYSLER 1971		PRE-TUNE																												
			POST-TUNE																												
7.	CHEVROLET 1965		PRE-TUNE	—	—	—	—	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
			POST-TUNE	—	—	—	—	OK	NG	OK	OK	NG	NG	OK	OK	OK	OK	OK		OK	OK	OK	OK	OK	OK	OK	NG	NG	NG	NG	OK
8.	FORD 1971		PRE-TUNE																												
			POST-TUNE																												
9.	CHEVROLET 1970		PRE-TUNE	NG	NG	NG	NG	—																							
			POST-TUNE	NG	OK	NG	OK	—																							
10.	AMERICAN MOTORS 1971		PRE-TUNE	NG	NG	NG	NG	—																							
			POST-TUNE	OK	NG	OK	OK	—																							

TABLE A-24

HEAT RISER CONDITION BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	LOCATION		SAN BERNARDINO																RIVERSIDE											
		REPAIR STATION		INDEPENDENT GARAGE					DEALER					SERVICE STATION						INDEPENDENT GARAGE				DEALER				SERVICE STATION			
		STATION NO		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5		1	2	3	4	1	2	3	4	1	2	3	4
		SPEC	STATE											EMISSION INSPECTION FLEET																	
1.	CHEVROLET 1964		PRE-TUNE	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG		NG	NG	—	—	NG	NG	—	—	NG	NG	—	—
			POST-TUNE	OK	NG	NG	NG	OK	NG	OK	OK	NG	OK	OK	OK	NG	OK	OK		NG	OK	—	—	OK	OK	—	—	OK	OK	—	—
2.	FORD 1970		PRE-TUNE																												
			POST-TUNE																												
3.	CHEVROLET 1971		PRE-TUNE																												
			POST-TUNE																												
4.	PLYMOUTH 1970		PRE-TUNE																												
			POST-TUNE																												
5.	VOLKSWAGEN 1971		PRE-TUNE																												
			POST-TUNE																												
														PARAMETER INSPECTION FLEET																	
6.	CHRYSLER 1971		PRE-TUNE	NG	NG	NG	—	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
			POST-TUNE	NG	NG	NG	—	NG	NG	NG	OK	NG	NG	NG	OK	NG	NG	NG		NG	NG	NG	NG	NG	OK	NG	NG	NG	NG	OK	NG
7.	CHEVROLET 1965		PRE-TUNE																												
			POST-TUNE																												
8.	FORD 1971		PRE-TUNE																												
			POST-TUNE																												
9.	CHEVROLET 1970		PRE-TUNE	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG		NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG	NG
			POST-TUNE	OK	NG	OK	NG	OK	OK	NG	OK	NG	OK	NG	OK	NG	NG	NG		NG	OK	NG	NG	NG	NG	OK	NG	NG	NG	NG	NG
10.	AMERICAN MOTORS 1971		PRE-TUNE																												
			POST-TUNE																												

TABLE A-25

NOX CONTROL DEVICE CONDITION BEFORE AND AFTER MAINTENANCE

CAR NO	MANUFACTURER AND YEAR	LOCATION		SAN BERNARDINO																RIVERSIDE									
		REPAIR STATION		INDEPENDENT GARAGE					DEALER					SERVICE STATION					INDEPENDENT GAR GE				DEALER				SERVICE STATION			
		STATION NO		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
		SPEC	STATE											EMISSION INSPECTION FLEET															
1.	CHEVROLET 1964		PRE-TUNE																										
			POST-TUNE																										
2.	FORD 1970		PRE-TUNE																										
			POST-TUNE																										
3.	CHEVROLET 1971		PRE-TUNE	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	—	—	IO	IO	—	—	IO	IO	—	—
			POST-TUNE	IO	IO	IO	IO	IO	OK	IO	IO	IO	OK	IO	OK	IO	IO	IO	IO	IO	—	—	OK	OK	—	—	IO	IO	—	—
4.	PLYMOUTH 1970		PRE-TUNE																										
			POST-TUNE																										
5.	VOLKSWAGEN 1971		PRE-TUNE																										
			POST-TUNE																										
														PARAMETER INSPECTION FLEET															
6.	CHRYSLER 1971		PRE-TUNE	IO	IO	IO	—	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO
			POST-TUNE	IO	IO	IO	—	IO	IO	IO	OK	IO	IO	IO	IO	IO	OK	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO
7.	CHEVROLET 1965		PRE-TUNE																										
			POST-TUNE																										
8.	FORD 1971		PRE-TUNE																										
			POST-TUNE																										
9.	CHEVROLET 1970		PRE-TUNE	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO
			POST-TUNE	IO	OK	OK	OK	IO	OK	OK	OK	IO	IO	IO	OK	IO	IO	IO	OK	IO	IO	IO	OK	OK	OK	IO	IO	IO	IO	IO
10.	AMERICAN MOTORS 1971		PRE-TUNE	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	—	IO	IO	IO	IO
			POST-TUNE	IO	IO	IO	OK	IO	IO	OK	OK	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	IO	—	IO	IO	IO	IO

TABLE A-26

REPAIR COST

CAR NO	MANUFACTURER AND YEAR	SPEC	STATE	SAN BERNARDINO															RIVERSIDE											
	LOCATION			INDEPENDENT GARAGE					DEALER					SERVICE STATION					INDEPENDENT GARAGE				DEALER				SERVICE STATION			
	REPAIR STATION																													
	STATION NO			1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4
				EMISSION INSPECTION FLEET																										
1.	CHEVROLET 1964		PRE-TUNE	6.99	13.84	15.54	18.35	12.06	43.44	29.67	44.61	19.33	58.58	6.39	25.26	8.19	10.90	20.00	16.78	12.09	—	—	16.95	43.23	—	—	38.83	19.56	—	—
			POST-TUNE																											
2.	FORD 1970		PRE-TUNE	34.44	6.00	30.81	10.50	33.95	7.20	10.00	50.31	9.00	42.48	9.50	19.90	5.95	60.91	29.26	11.65	18.35	—	—	38.06	49.06	—	—	69.43	11.00	—	—
			POST-TUNE																											
3.	CHEVROLET 1971		PRE-TUNE	0	5.00	9.00	15.00	7.00	25.99	29.11	32.00	14.30	30.95	7.50	20.75	8.00	8.95	19.70	7.50	8.00	—	—	14.50	38.91	—	—	35.22	11.00	—	—
			POST-TUNE																											
4.	PLYMOUTH 1970		PRE-TUNE	0	0	13.60	12.50	29.56	1.50	32.79	68.54	3.60	26.79	11.96	14.35	12.34	20.30	15.75	18.54	8.00	—	—	18.55	67.98	—	—	46.73	15.33	—	—
			POST-TUNE																											
5.	VOLKSWAGEN 1971		PRE-TUNE	10.30	6.35	13.85	19.50	15.35	13.75	1.42	—	—	33.96	8.85	23.90	10.35	3.95	20.69	23.90	—	—	—	22.53	28.00	—	—	35.44	12.35	—	—
			POST-TUNE																											
				PARAMETER INSPECTION FLEET																										
6.	CHRYSLER 1971		PRE-TUNE	13.75	7.00	37.00	19.00	7.00	19.00	9.00	46.89	48.88	26.71	12.50	19.50	12.50	12.00	29.40	75.55	23.70	28.51	22.26	23.81	19.30	13.50	26.50	10.50	7.50	5.50	23.70
			POST-TUNE																											
7.	CHEVROLET 1965		PRE-TUNE	15.62	11.89	37.09	21.10	12.37	10.12	16.63	41.18	37.41	27.43	9.15	22.26	21.42	22.45	37.85	69.99	26.93	32.11	14.51	31.75	16.25	43.23	20.50	7.50	10.70	0	17.12
			POST-TUNE																											
8.	FORD 1971		PRE-TUNE	36.36	16.96	68.39	17.37	10.50	19.19	18.85	25.15	45.93	46.12	10.13	32.32	31.98	29.02	13.51	92.20	25.45	37.61	21.68	15.92	30.78	52.54	28.15	14.15	10.90	7.10	34.60
			POST-TUNE																											
9.	CHEVROLET 1970		PRE-TUNE	22.50	15.31	33.65	19.47	8.61	34.60	19.98	29.79	39.32	43.77	8.15	25.89	15.80	39.07	10.85	76.49	20.85	31.56	28.67	96.98	19.16	39.63	31.80	9.35	9.50	9.10	21.35
			POST-TUNE																											
10.	AMERICAN MOTORS 1971		PRE-TUNE	17.50	7.00	30.90	19.28	7.00	10.00	27.71	11.78	24.96	26.71	6.50	21.01	12.50	8.00	7.50	50.45	19.20	27.29	16.00	20.93	9.00	26.50	—	0	7.50	0	15.89
			POST-TUNE																											

Table A-27

KEY MODE EMISSIONS AND ASSOCIATED TRUTH CHARTS

EMISSION INSTRUCTION FLEET WITH MALFUNCTIONS

Vehicle No.	45/49 mph* CO	45/49 mph* HC	30/33 mph* CO	30/33 mph* HC	idle* CO	idle* HC	Truth Charts Accompanying Vehicles
1	[3.3-4.0]	432-583	[3.6-4.3]	478-524	8.6-10.0	[775-1650]	1, 5, 7
2.	[0.23]	[618]	0.6	[812]	3.7	[1087]	4, 5
3	[0.4-2.5]	[1534-1617]	[0.4-3.9]	[1330-1650]	4.0-4.1	[1000-1909]	4, 6
4	0.85-1.4	115-184	1.6-8.9	[130-427]	[3.4-4.3]	[398-455]	2, 5
5	[1.6-2.7]	[432-4850]	[1.2-1.9]	[042-3224]	1.0-2.7	[690-3970]	4, 7

[ ] Key modes failed

*Co in % by volume, HC in ppm by volume using Clayton, Key Modes